STANDARD SPECIFICATIONS AND CODE OF PRACTICE FOR ROAD BRIDGES

SECTION : IX

BEARINGS
PART III : POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS

THE INDIAN ROADS CONGRESS
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BEARINGS
PART III: POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS

INTRODUCTION

The Committee on Bearings, Joints and Appurtenances (B-5 Committee) formulated a Sub-committee comprising of S/Shri A. Chakrabarti (Chairman), S. Dutta, A.R. Jambekar, A.K. Gupta, M.V.B. Rao and S. Majumdar for preparing the base draft on POT, POT-cum-PTFE, PIN and Metallic Guide Bearings. The draft prepared by the Sub-committee was discussed by the B-5 Committee and finalised the same during its meetings held on the 12th October, 2000. The Committee consisted of the following personnel:

N.K. Sinha	Convenor
Krishan Kant	Co-Convenor
R.S. Ninan	Member-Secretary

Members

A.K. Banerjee	A.K. Gupta
B.K. Basu	A.R. Jambekar
C.C. Bhattacharya	S.K. Kaistha
A. Chakrabarti	Dr. Krishan Kumar
S.P. Charkrabarti	P.Y. Manjure
S. Dutta	N. Raghavan
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Rajiv Goel	V. Velayutham

Rep. of BIS

Ex-Officio Members

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Secretary, IRC
(G. Sharan)

Corresponding Members

V.P. Deshpande	Dr. V.K. Raina
M.K. Mukherjee	A.S. Prasada Rao

P.S. Tyagi

The Bridges Specifications and Standards Committee in its meeting held on the 14th July, 2001 approved the draft subject to certain modifications in the light of the comments made by members. The draft was approved by the Executive Committee in its meeting held on the 16th December, 2001 and later by the Council of the Indian Roads Congress in its 164th Meeting held at Kochi on the 8th January, 2002.

IRC:83, Standard Specifications and Code of Practice for Road Bridges, Section IX is being brought out in four parts, Part I deals with Metallic Bearings, Part II with Elastomeric Bearings, Part III with POT, POT-cum-PTFE, PIN and Metallic Guide Bearings and Part IV with Expansion Joints.

The Part I of the Code relating to Metallic Bearings and Part II relating to Elastomeric Bearings have already been published as IRC:83-Parts I & II respectively.

922. SCOPE

922.1. This section of the code deals with requirements for the materials, design, manufacture, testing, installation and maintenance of POT, PTFE, PIN and Metallic Guide Bearings for Road Bridges. The provisions of this code are meant to serve as a guide to both design and construction engineers, but mere compliance with the provisions stipulated herein will not relieve them in any way of their responsibility for the stability and soundness of the structure designed and erected.

922.2. The provision of this code shall apply for operating temperature between -10°C and +50°C.

922.3. Pot bearings with confined elastomeric pressure

pads upto 1500 mm diameter are within the scope of this code.

922.4. Bearings which are subjected to tensile loads are beyond the scope of this code.

922.5. Bearings which are subjected to rotations greater than 0.025 radians are beyond the scope of this code.

923. TERMINOLOGY

923.1. **Pot Bearing**

A bearing consisting of a metal piston supported by a disc of unreinforced elastomer that is confined within a metal cylinder for allowing rotational movement about any axis in horizontal plane and to bear and transmit vertical load. Pot bearings may be provided with sliding assembly (with or without restraint in the form of guide along a desired direction to bear and transmit horizontal force) comprising of stainless steel plate attached to metal backing plate sliding in horizontal plane over PTFE confined in recess(s) on the piston which shall be termed as Pot-cum-PTFE bearings. Depending on the desired degree of freedom Pot bearings may be of three types as follows:

923.1.1. **Fixed type pot bearing:** A type of Pot bearing which alongwith vertical load, bears and transmits horizontal force in any direction and allows rotation about any axis in horizontalplane without permitting any movement in horizontal plane (Fig. 13).

923.1.2. **Free sliding type pot-cum-PTFE bearing:** A type of Pot bearing which bears and transmits vertical load and allows movement in any direction in the horizontal plane and accommodates rotation about any axis in horizontal plane (Fig. 14).

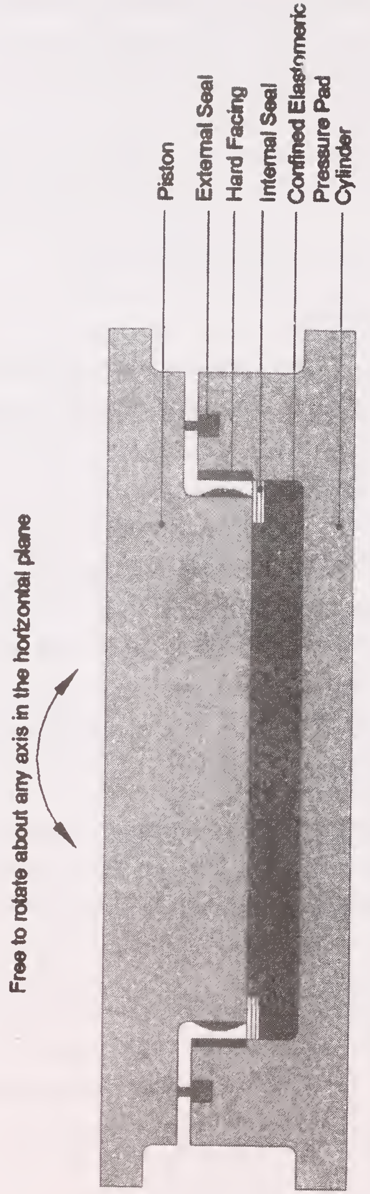


Fig. 13. Fixed type pot bearing

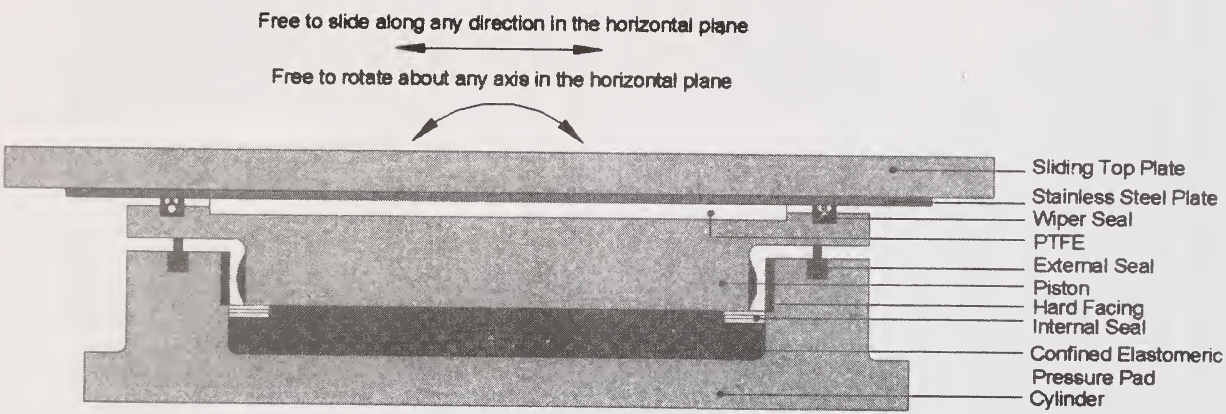


Fig. 14. Free sliding type pot-cum-PTFE bearing

923.1.3. **Guided sliding type POT-cum-PTFE bearing:** A type of Pot bearing which alongwith vertical load bears and transmits horizontal force in one direction only and allows movement perpendicular to that direction and allows rotation about any axis in horizontal plane (Fig. 15).

923.2. **PTFE Sliding Assembly**

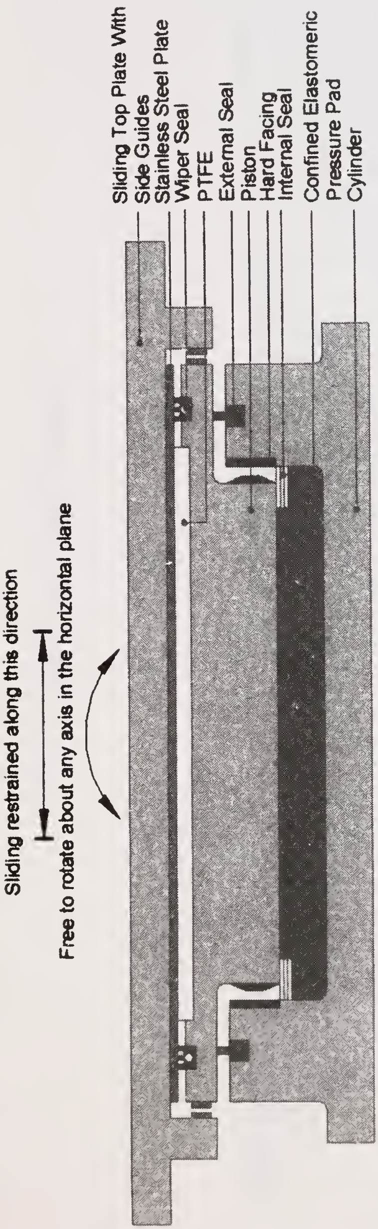
A bearing consisting of a sliding assembly (with or without restraint in the form of guide along a desired direction to bear and transmit horizontal force) comprising of stainless steel plate attached to a metal backing plate sliding in horizontal plane over PTFE confined in recess(s) on a fixed plate. PTFE sliding assemblies are capable to bear and transmit vertical load but are not capable to accommodate rotational movement unless provided with additional arrangement. Depending on the desired degree of freedom PTFE sliding assemblies may be of two types as follows:

923.2.1. **Free PTFE sliding assembly:** A type of PTFE sliding assembly which bears and transmits vertical load and allows movement in any direction in the horizontal plane (Fig. 16).

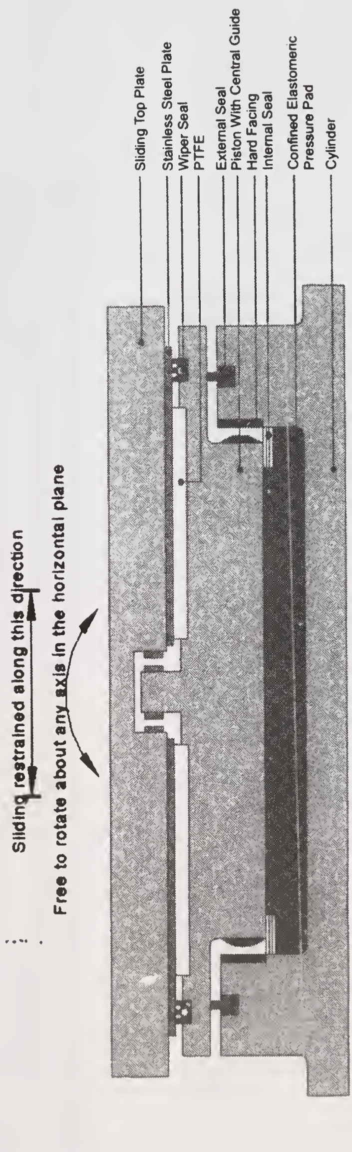
923.2.2. **Guided PTFE sliding assembly:** A type of PTFE sliding assembly which alongwith vertical load bears and transmits horizontal force in one direction and allows movement perpendicular to that direction (Fig. 17).

923.3. **Pin Bearing**

A bearing consisting of a metal pin provided within a metal cylinder to bear and transmit horizontal force along any direction in the horizontal plane and accommodating rotational movement about any axis. Pin bearings cannot bear or transmit any vertical load (Fig. 18).



a) With Side Guides



b) With Central Guide

Fig. 15. Guided sliding type pot-cum-PTFE bearing

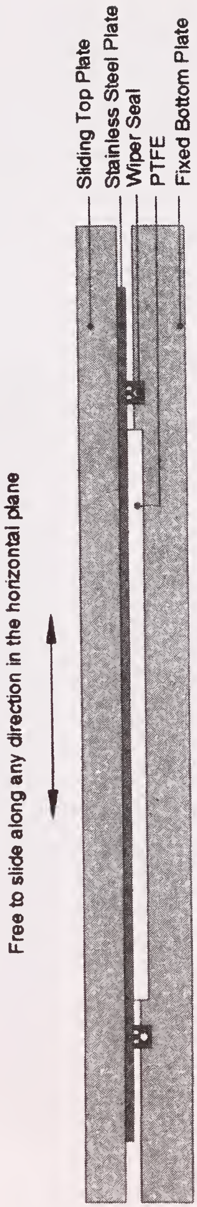


Fig. 16. Free PTFE sliding assembly

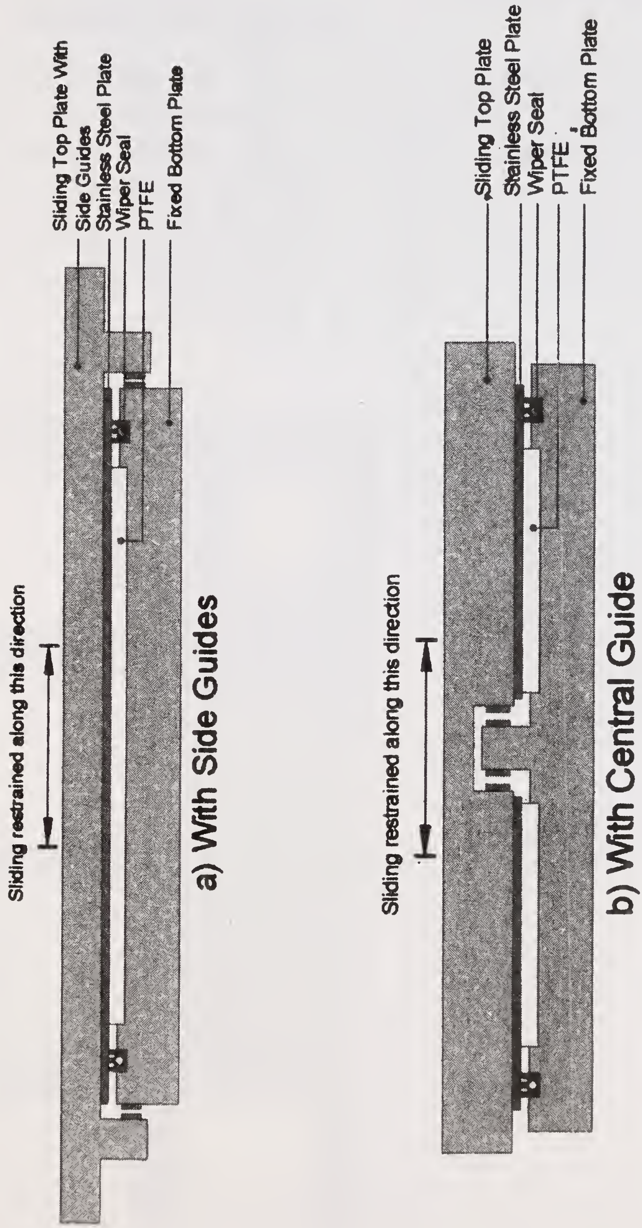


Fig. 17. Guided PTFE sliding assembly

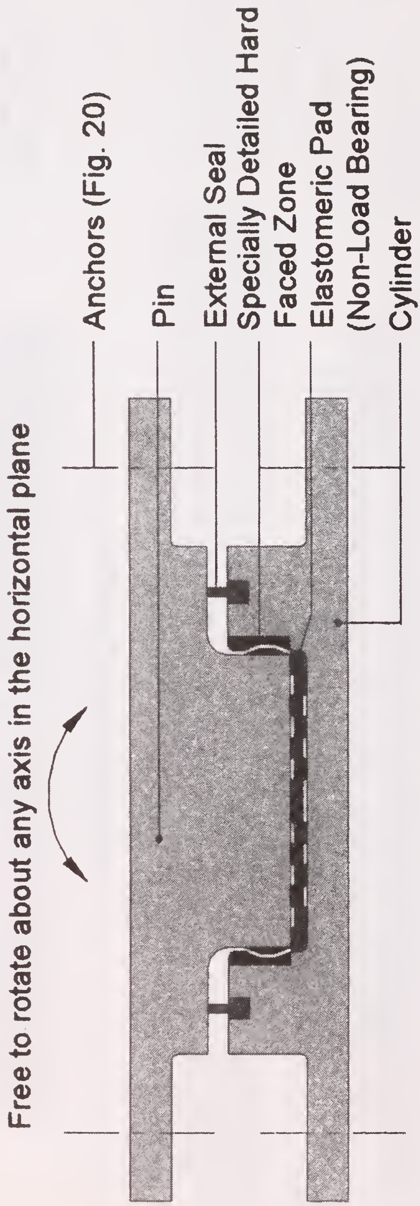


Fig. 18. Pin bearing

923.4. Metallic Guide Bearing

A bearing consisting of a sliding assembly with restraint along a desired direction to bear and transmit horizontal force and capable of allowing movement in a direction perpendicular to the direction of horizontal force. Metallic Guide bearings are capable of allowing rotation only about an axis perpendicular to the plane of sliding. Metallic Guide bearing cannot bear or transmit any vertical load (Fig. 19).

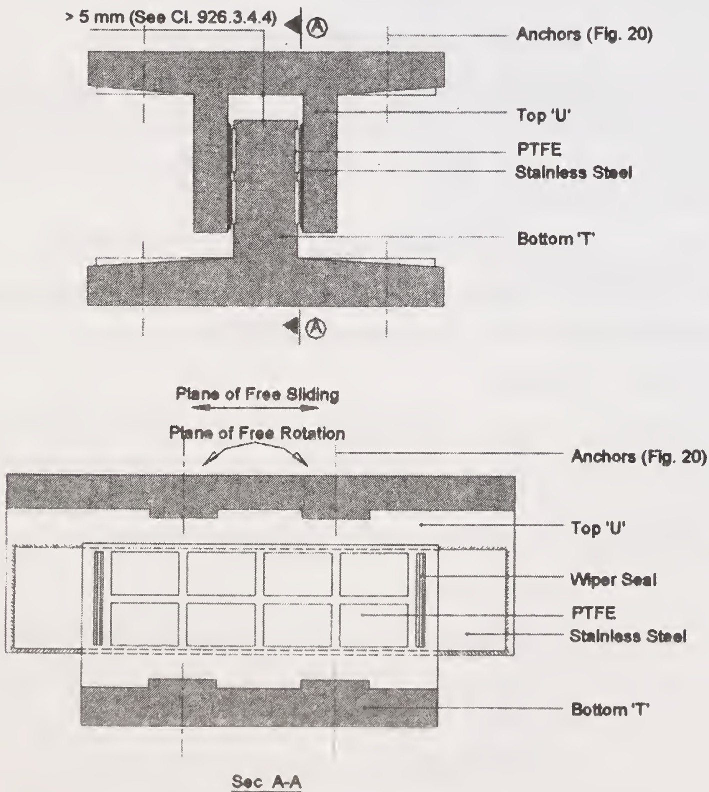


Fig. 19. Metallic guide bearing

923.5. **Cylinder**

A metallic cylindrical component provided with a monolithic base plate which houses the elastomeric pressure pad and piston for Pot bearings and the Pin for Pin bearings.

923.6. **Piston**

The metallic component of a Pot bearing which is housed inside the cylinder and confines the elastomeric pressure pad. For sliding (free or guided) type Pot-cum-PTFE bearings, the piston is provided with recess(s) at the top to accommodate and confine PTFE.

923.7. **Confined Elastomeric Pressure Pad**

A disc of unreinforced elastomer that is confined within the cylinder by the piston of Pot bearings for accommodating rotational movement about any axis in horizontal plane and to bear and transmit vertical load.

923.8. **Sliding Component**

A component comprising of stainless steel plate attached to a metal backing plate for sliding over PTFE.

923.9. **Guide**

Monolithic metallic projection either from the piston which fits into a corresponding recess in the sliding component or from the sliding component parallel to two opposite edges of the piston, to bear and transmit horizontal force along a direction.

923.10. **Internal Seal**

A sealing arrangement between piston and cylinder of Pot and Pot-cum-PTFE Bearings to prevent the extrusion of confined elastomer, under load.

923.11. **External Seal**

A sealing arrangement provided for preventing ingress of moisture and debris through the gap between the piston and cylinder

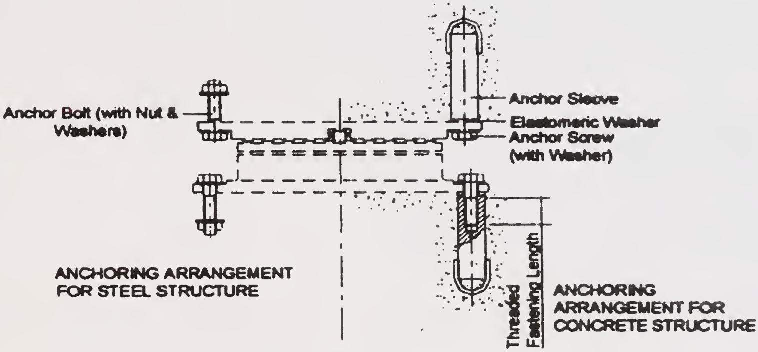
for Pot bearings and that through the gap between the pin and cylinder for Pin bearings.

923.12. **Wiper Seal**

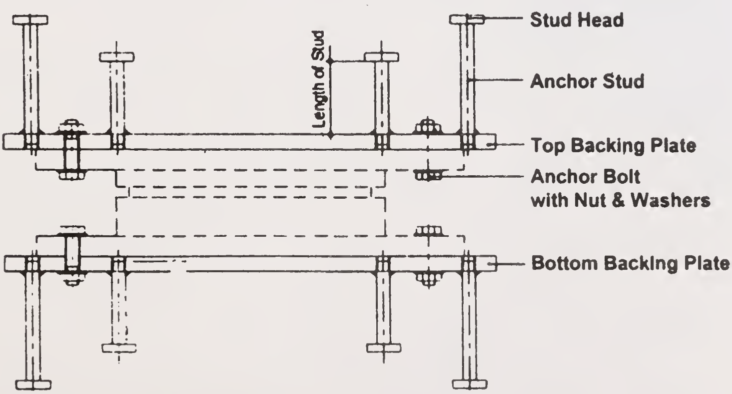
A sealing arrangement provided for retaining the lubrication and preventing contamination of the sliding surfaces.

923.13. **Anchoring Arrangement**

An arrangement provided to fix the bearing to the structure (Fig. 20).



(a) Anchoring Arrangement with Bolt-Nut/Screw-Sleeve System



(b) Anchoring Arrangement with Backing Plates & Studs

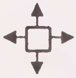
Fig. 20. Anchoring arrangement

923.14. **Preset**

Setting of sliding component to a predetermined position with respect to its mean position.

924. SYMBOLS AND NOTATIONS

924.1. Symbolic Representation of Bearing Function

Symbol	Bearing Type	Resists Vertical Load	Resists Horizontal Force Along Direction (In The Horizontal Plane)	Permits Translation Along Direction (In The Horinzontal Plane)	Permits Rotation Axis (In The Horizontal Plane)
	Fixed Pot	Yes	Any	No	Any
	Free Sliding Pot-cum-PTFE	Yes	No	Any	Any
	Guided Sliding Pot-cum-PTFE	Yes	Uni-directional	Uni-directional	Any
	Free PTFE Sliding Assembly	Yes	No	Any	No
	Guided PTFE Sliding Assembly	Yes	Uni-directional	Uni-directional	No
	Pin	No	Any	No	Any
	Metallic Guide	No	Uni-directional	Uni-directional	Uni-directional

924.2. Notations

H	=	Design Horizontal Force, in N.
μ	=	Coefficient of Friction at PTFE-Stainless Steel Sliding Interface
θ	=	Design Rotation Angle, in Radian = 1.3 $(\theta p + \theta v)$
θp	=	Calculated Value of Resultant Rotation Angle due to Permanent Actions and Long Term Effects, in Radian.
θv	=	Calculated Value of Resultant Rotation Angle due to Variable Actions, in Radian.
k_1, k_2	=	Constants for Determining Induced Moments due to Tilting Stiffness of Confined Elastomeric Pressure pad.
$M_{e.d}$	=	Induced Moment due to Tilting Stiffness, in N-mm.
$M_{R.d}$	=	Induced Moment due to Frictional Resistance, in N-mm.
$M_{T.d}$	=	Total Induced Moment, in N-mm.
di	=	Diameter of Confined Elastomeric Pressure Pad, in mm.
he	=	Thickness of Confined Elastomeric Pressure Pad, in mm.
bp	=	Thickness of Cylinder Wall of Pot and Pin Bearing, in mm.
hc	=	Height of Cylinder Wall of Pot and Pin Bearing, in mm.
R	=	Radius of Curvature of the Curved Contact Surface of Piston and Cylinder for Pot Bearing, in mm.
dc	=	Inner Diameter of Cylinder of Pin Bearing, in mm.

dn	=	Diameter of Pin of Pin Bearing, in mm.
ha	=	Height of Line of Application of Design Horizontal Force from Cylinder Wall above Base Interface of Pot and Pin Bearing, in mm.
w	=	Width of Contact Surface of the Piston for Pot Bearing and the Pin for Pin Bearing, in mm.
w_e	=	Effective Width of Contact Surface of Piston and Cylinder for Pot Bearing and Pin and Cylinder for Pin Bearing, in mm.
Ab,eff	=	Effective Tensile Area of the Bolt/ Screw, in mm².
D	=	Diameter of Anchor Sleeve, in mm.
L	=	Length of Anchor Sleeve, in mm.
σce	=	Fluid Pressure in Confined Elastomeric Pressure Pad Due to Vertical Load, in MPa.
*f*ck	=	The Characteristic Compressive Strength of Concrete, in MPa.
Ec	=	Short Term Static Modulus of Elasticity of Concrete, in MPa.
Ece	=	Modulus of Elasticity of Concrete for Permanent Load Effect, in MPa.
σco	=	Permissible Direct Compressive Stress in Concrete, in MPa.
A_2	=	Loaded Area, in mm².
A_1	=	Dispersed Concentric Area, in mm².
σcc	=	Average Permissible Direct Bearing Pressure in Concrete, in MPa.
σc	=	Permis Sible Compressive Flexural Stress in Concrete, in MPa.

$\sigma_{cc,cal}$ = Calculated Direct Compressive Stress in Concrete, in MPa.

$\sigma_{c,cal}$ = Calculated Compressive Flexural Stress in Concrete, in MPa.

σ_{cpk} = Peak Stress in Concrete Behind Anchor Sleeve, in MPa.

f_y = Minimum Yield Stress of Steel, in MPa.

E_s = Static Modulus of Elasticity of Steel, in MPa.

σ_u = Ultimate Tensile Strength of Steel, in MPa.

σ_{at} = Permissible Stress in Axial Tension in Steel, in MPa.

σ_{bt} = Permissible Stress in Bending Tension in Steel, in MPa.

σ_{bc} = Permissible Stress in Bending Compression in Steel, in MPa.

τ_{vm} = Permissible Shear Stress in Steel, in MPa.

σ_p = Permissible Bearing Stress in Steel, in MPa.

σ_e = Permissible Equivalent Stress in Steel, in MPa.

$\sigma_{at,cal}$ = Calculated Stress in Axial Tension in Steel, in MPa.

$\sigma_{bt,cal}$ = Calculated Stress in Bending Tension in Steel, in MPa.

$\sigma_{bc,cal}$ = Calculated Stress in Bending Compression in Steel, in MPa.

$\tau_{vm,cal}$ = Calculated Shear Stress in Steel, in MPa.

$\sigma_{p,cal}$ = Calculated Bearing Stress in Steel, in MPa.

$\sigma_{e,cal}$	=	Calculated Equivalent Stress in Steel, in MPa.
σ_{tf}	=	Permissible Stress in Axial Tension in Bolts and Screws, in MPa.
τ_{vf}	=	Permissible Shear Stress in Bolts and Screws, in MPa.
σ_{pf}	=	Permissible Bearing Stress in Bolts and Screws, in MPa.
$\sigma_{tf,cal}$	=	Calculated Stress in Axial Tension in Bolts and Screws, in MPa.
$\tau_{vf,cal}$	=	Calculated Shear Stress in Bolts and Screws, in MPa.
$\sigma_{pf,cal}$	=	Calculated Bearing Stress in Bolts and Screws, in MPa.
σ_{at}^{1}	=	Hoop Tensile Stress in Cross-Section of Cylinder Wall due to Fluid Pressure, in MPa.
σ_{at}^{2}	=	Hoop Tensile Stress in Cross-Section of Cylinder Wall due to Horizontal Force, in MPa.
τ_{vm}^{1}	=	Shear Stress at Cylinder Wall and Base Interface due to Fluid Pressure, in MPa.
τ_{vm}^{2}	=	Shear Stress at Cylinder Wall and Base Interface due to Horizontal Force, in MPa.
σ_{bt}^{1}	=	Bending Stress at Cylinder Wall and Base Interface due to Fluid Pressure, in MPa.
σ_{bt}^{2}	=	Bending Stress at Cylinder Wall and Base Interface due to Horizontal Force, in MPa.
$\sigma_{p,Hertz}$	=	The Effect of Hertz Stress at the Mating Interface of Pin and Cylinder of Pin Bearing, in MPa.

925. MATERIALS

925.1. **Steel**

925.1.1. Mild steel to be used for the components of the bearings shall generally comply with Grade B of IS:2062. However, Grade C of IS:2062 shall be used for sub-zero condition.

925.1.2. High tensile steel to be used for the components of the bearings shall comply with IS:961.

925.1.3. Cast steel shall generally comply with Grade 280-520W or 340-570W of IS:1030.

925.1.4. The steel for forging to be used for the components of the bearings shall comply with Class 3, 3A or 4 of IS:1875 and steel forgings shall comply with Class 3, 3A or 4 of IS:2004 and normalised.

925.1.5. Stainless steel shall conform to AISI 316L or $O_2Cr_{17}Ni_{12}Mo_2$ of IS:6911.

925.2. **PTFE**

The raw material for PTFE shall be pure polytetrafluoroethylene free sintered without regenerated materials or fillers. The mechanical and physical properties of unfilled PTFE shall comply with Grade A of BS:3784 or equivalent. PTFE shall either be in the form of solid rectangular modules (Fig. 21) or dimpled large sheet (Fig. 22). For PTFE sheets provided with lubrication cavities in the form of dimples, the dimples shall be formed by hot pressing or moulding and the pattern of dimples shall be as shown in Fig. 22. Use of PTFE sheet with dimples made by machining or drilling from a solid PTFE sheet is not permitted. The surface of PTFE sheets/modules to be in contact

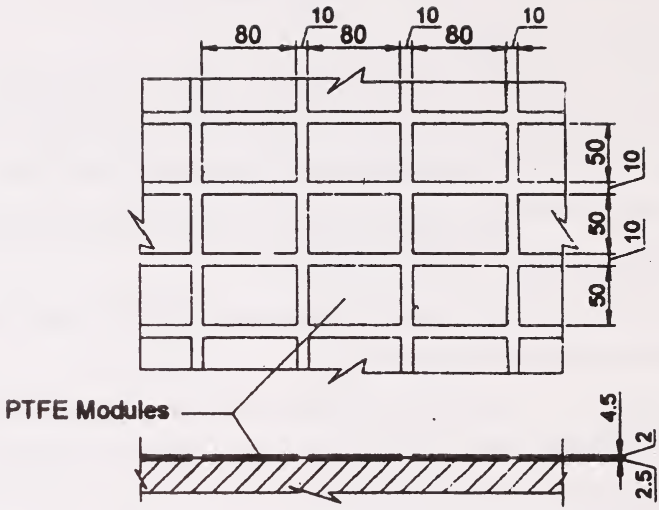


Fig. 21. Typical arrangement of modular PTFE

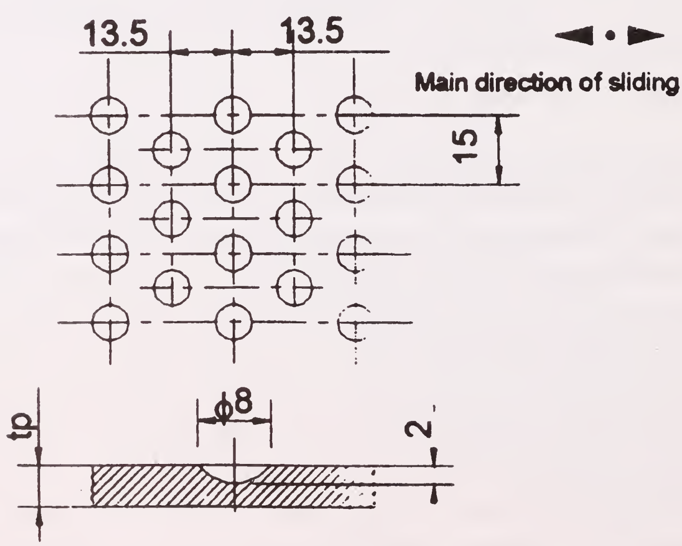


Fig. 22. Pattern of dimples in recessed PTFE sheet

with metal backing plate shall be provided with suitable chemical treatment for proper bonding. Adhesives for bonding PTFE to backing plates shall produce a bond with a minimum peel strength of 4N/mm width when tested in accordance with BS: 5350:(Part C9).

925.3. **Composite Material**

For guide of Pot bearings composite material may be used for sliding on stainless steel to achieve lower coefficient of friction as compared to stainless steel sliding on stainless steel and higher compressive strength as compared to PTFE, such composite material shall either consist of (i) a bronze backing strip and a sintered inter-locking porous matrix, impregnated and overlaid with a PTFE/lead mixture or (ii) a mixture of PTFE, glass fibre and graphite embedded in a bronze mesh which is bonded to a galvanised steel backing strip.

925.4. **Elastomer**

The elastomer to be used for the components of bearings shall generally comply with IRC:83 (Part II). The confined elastomer of Pot bearings shall have the properties specified in Table 1.

Table 1. Properties of Confined Elastomer

Property	Unit	Test method, I.S. specification reference	Limiting values
(1)	(2)	(3)	(4)
1. Hardness	IRHD	IS:3400 (Part II)	50 ± 5
2. Minimum tensile strength	MPa	IS:3400 (Part I)	15.5
3. Minimum elongation at break		Ref. Table 1 of IRC:83 (Part II)-1987	
4. Maximum compression set		-do-	
5. Accelerated ageing		-do-	

925.5. Internal Seal

To prevent the extrusion of confined elastomer, under load, between piston and cylinder of Pot bearing, internal seal shall be provided which shall either be brass sealing ring (Fig. 23) or imported proven type Poly Oxy Methylene (POM) sealing chain. Brass sealing ring shall be made of metallic brass conforming to IS:410 and in accordance with Clause 927.2.7. Poly Oxy Methylene sealing chain shall consist of individual interlocking elements made of moulded polyoxymethylene having properties specified in Table 2 and dimensions as given in Fig. 24.

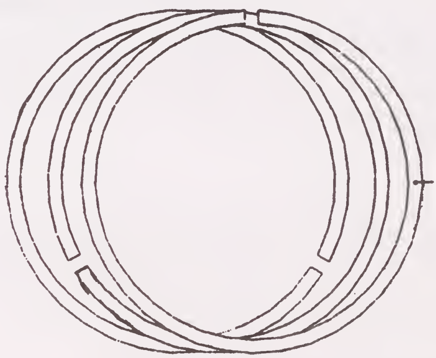
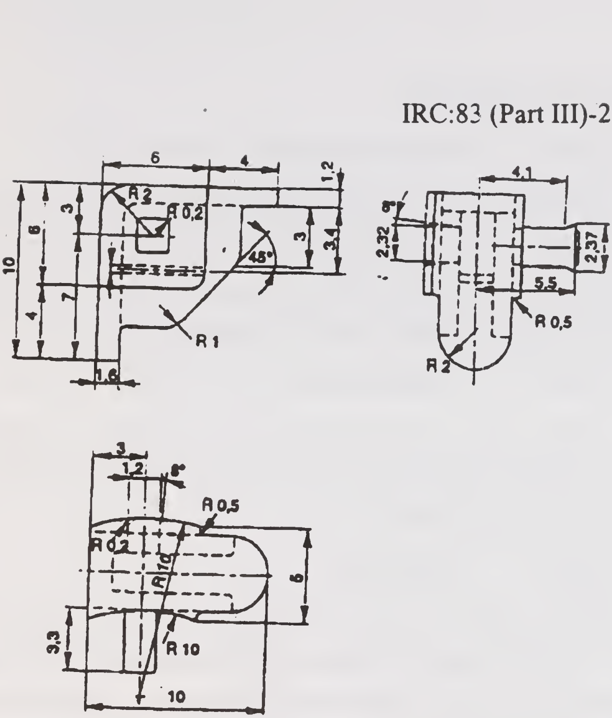


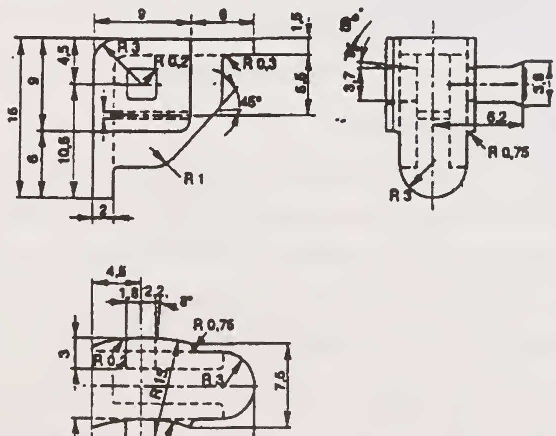
Fig. 23. Brass sealing ring

Table 2. Physical and Mechanical Properties of POM

Property	In accordance with	Requirements
Density	ISO:1183-1987	1410 kg/m^3 ± 6.0 kg/m^3
Melt flow index MFI 190/2, 16	ISO:1133-1981	10 g/min ± 2.0 g/min
Ultimate tensile strength	ISO:572:2-1986	62 N/mm^2 minimum
Ultimate strain	ISO:572:2-1986	30 % minimum



(a) Small POM element (For diameter of elastomeric pad up to 550 mm)



All dimensions are in mm.

(b) Large POM element (For diameter of elastomeric pad above 550 mm)

Fig. 24. Dimensions of POM sealing elements

925.6. **External Seal**

External seal of suitable profile made of elastomer shall be provided for preventing ingress of moisture and debris through the gap between the piston and cylinder for Pot bearings and that of the pin and cylinder for Pin bearings (Figs. 13 to 15 and 18).

925.7. **Wiper Seal**

Wiper seal of suitable profile made of elastomer shall be provided for retaining the lubrication and preventing contamination of the sliding surfaces.

925.8. **Fasteners**

Bolts, screws, nuts and lock nuts shall generally conform to IS:1363, IS:1364, IS:1365, IS:2269, IS:3138, IS:6761, IS:6639 as appropriate with mechanical properties conforming to IS:1367. Threads shall generally conform to IS:4218. Washers shall conform to IS:2016, IS:6610 as appropriate.

926. DESIGN

926.1. **General**

926.1.1. Local effects of load/force and movements to be considered in designing the bearings shall be determined by suitable global analysis of the structure with idealised boundary condition under any critical combination of loads and forces that can coexist in accordance with the requirements of IRC:6.

926.1.2. Resistance due to friction at the sliding interface of the bearing, if any, shall be ignored for idealising the boundary conditions in global analysis of the structure. However, induced force generated due to friction at sliding interface shall be considered in the design of bearings and adjacent (supported/ supporting) structures.

926.1.3. Coexisting values of load/movement data for design of bearings shall be furnished for permanent load condition, maximum vertical load condition, minimum vertical load condition, maximum horizontal force condition and maximum rotation condition as appropriate for different type of bearings, specifying the respective load case, i.e., Normal or Wind or Earthquake. Refer ***Appendix-1***, 'Typical Format of Furnishing Data for Design of Bearings'.

926.1.4. For design of Pot bearings or part thereof the design horizontal force to be considered shall be the resultant of the coexisting active horizontal forces, determined from global analysis, and induced horizontal forces, generated due to friction at sliding interface (if any), but shall in no case be less than 10 per cent and greater than 25 per cent of the design vertical load.

926.1.5. For design of bearings or part thereof and the adjacent structures the resultant of the coexisting moments produced due to design horizontal force and that induced due to resistance to rotation shall be considered.

926.1.5.1. Induced moment resulting from resistance to rotation due to the effect of tilting stiffness of elastomeric pressure pad shall be determined as follows:

$$M_{e,d} = di^3 \times (k_1.\theta p + k_2.\theta v),$$

Where,

di = diameter of elastomeric pressure pad in mm

he = thickness of confined elastomeric pressure pad in mm.

k_1 and k_2 shall be as per Table 3. Intermediate values may be obtained by linear interpolation.

θp = calculated value of resultant rotation angle due to permanent actions and long term effects, in radian

θv = calculated value of resultant rotation angle due to variable actions, in radian, and

$M_{e,d}$ = induced moment in N-mm.

TABLE 3. VALUES OF CONSTANTS k_1 AND k_2

di/he	k_1	k_2
15	2.2	101
12.5	1.8	58.8
10	1.5	30.5
7.5	1.1	13.2

926.1.5.2. Induced moment resulting from resistance to rotation due to friction at the piston-cylinder contact surface due to coexisting horizontal force shall be determined as follows:

$$M_{R,d} = 0.2 \times C \times H,$$

Where,

- C = the perpendicular distance from the point of action of horizontal force on cylinder wall to the axis of rotation in mm, Fig. 25.
- H = design horizontal force in N
- $M_{R,d}$ = induced moment in N-mm.

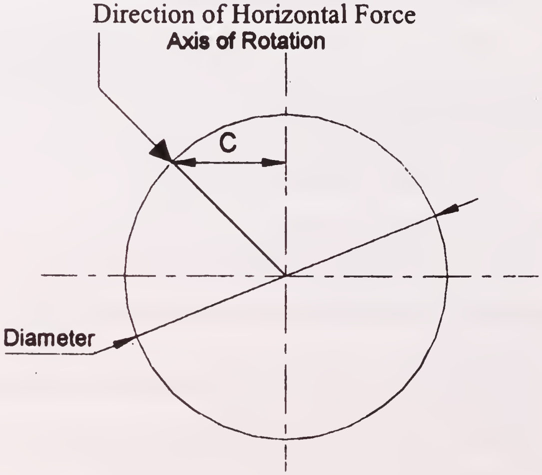


Fig. 25. Moment arm for rotation resistance due to friction

926.1.5.3. For Pot bearings total induced moment will be $M_{T,d} = M_{e,d} + M_{R,d}$ and for Pin bearings total induced moment will be $M_{T,d} = M_{R,d}$.

926.1.6. Design values of rotational and translational movement shall be determined by multiplying the respective calculated values by a factor of 1.3.

926.1.7. The line of action of resultant horizontal force shall be considered at the middle of the contact width (Clauses 926.3.1.3 and 926.3.3.2) of the piston and cylinder for Pot bearings and that of the pin and cylinder for Pin bearings.

926.2. Design Parameter

926.2.1. Permissible stresses on the adjacent concrete structure

926.2.1.1. Average permissible direct bearing pressure σcc on the adjacent concrete structure shall be calculated using the following equation:

$$\sigma cc = \sigma co \sqrt{(A_1/A_2)}$$

σco= permissible direct compressive stress in concrete = 0.25 $f$ck, where $f$ck is the characteristic compressive strength of concrete.

A_1 = dispersed concentric area, which is geometrically similar to the loaded area A_2 and also the largest area that can be contained in a plane of A_1 (maximum width of dispersion beyond the loaded area face shall be limited to twice the height).

A_2 = loaded area and,

$$\sqrt{(A_1/A_2)} \leq 2$$

The projection of the adjacent structure beyond the loaded area shall not be less than 150 mm. Adequate reinforcement for spalling and bursting tension shall be provided.

926.2.1.2. Permissible compressive flexural stress σc on the adjacent concrete structure shall be 0.33 *f*ck.

926.2.1.3. In case of coexisting direct and flexural compressive stresses on the adjacent concrete structure, the following criteria should be satisfied:

$$\sigma cc, cal/\sigma cc + \sigma c, cal/\sigma c \leq 1$$

Where,

σcc, cal = calculated direct compressive stress,

σc, cal = calculated compressive flexural stress.

926.2.1.4. When the effect of wind or earthquake is taken into account, the above permissible stresses may be increased by 25 per cent.

926.2.2. **Permissible stresses in steel**

926.2.2.1. Permissible stress in axial tension σat shall not exceed 0.6 *f*y, where *f*y = minimum yield stress of steel in MPa.

926.2.2.2. Maximum bending stress in tension (σbt) or in compression (σbc) in extreme fibre shall not exceed 0.66 *f*y.

926.2.2.3. Maximum shear stress (τvm) shall not exceed 0.45 *f*y.

926.2.2.4. Maximum bearing stress (σp) shall not exceed 0.75 *f*y.

926.2.2.5. Irrespective of any increase in the permissible stress specified in Clause 926.2.2.6, the equivalent stress (σe) due to coexisting bending (tension or compression) and shear stress

obtained from the following formula and shall not exceed 0.9 fy.

$$\sigma e,cal = \sqrt{(3 \times \tau vm,cal^2 + \sigma bt,cal^2)} \text{ or}$$

$$\sigma e,cal = \sqrt{(3 \times \tau vm,cal^2 + \sigma bc,cal^2)}$$

Where,

$\tau vm,cal$	=	calculated value of shear stress in MPa,
$\sigma bt,cal$	=	calculated value of bending stress in tension in MPa,
$\sigma bc,cal$	=	calculated value of bending stress in compression in MPa,
$\sigma e,cal$	=	calculated value of combined stress in MPa.

926.2.2.6. When the effect of wind or earthquake is taken into account the above permissible stresses shall not be increased.

926.2.2.7. The above permissible values are also applicable for stresses on steel structure, adjacent to the bearing.

926.2.3. Particular recommendations for confined elastomeric pressure pad

926.2.3.1. Permissible limits for confined elastomeric pressure pad depend on the effectiveness of the internal seal preventing it from extruding between the piston and the cylinder wall and as such shall be verified by load testing of assembled bearing.

926.2.3.2. Average stress in confined elastomeric pressure pad of Pot bearing shall not exceed 35 MPa and extreme fibre pressure shall not exceed 40 MPa.

926.2.3.3. Minimum average stress in confined elastomeric pressure pad of Pot bearing, under any critical combination of loads and forces that can coexist, shall in no case be less than 5 MPa.

926.2.3.4. The dimension of the confined elastomeric pressure pad shall be such that at design rotation the deflection at the perimeter shall not exceed 15 per cent of the pad thickness below the internal seal, Fig. 26.

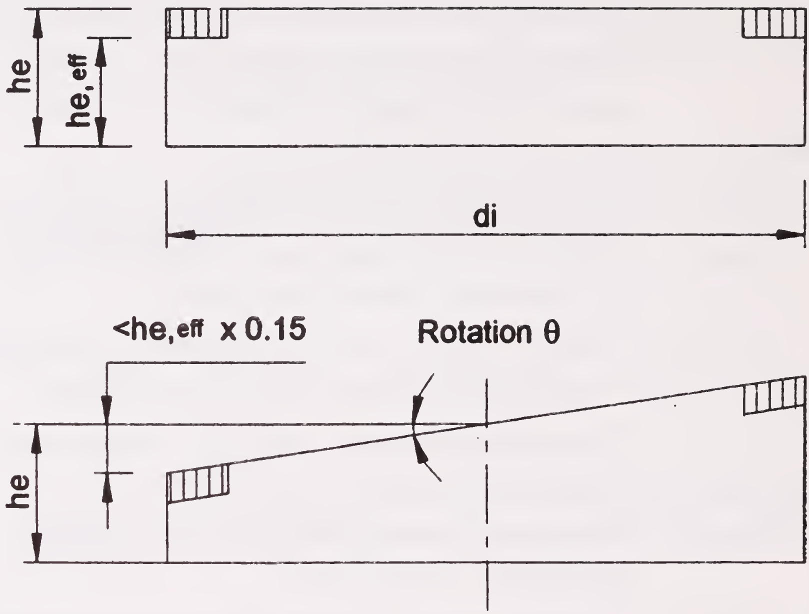


Fig. 26. Allowable strain in elastomeric pressure pad

926.2.3.5. No increase in permissible limits of stresses and strain is allowed for seismic, wind or any other load combinations.

926.2.3.6. The minimum thickness of the confined elastomeric pressure pad shall not be less than 1/15th of its diameter or 16 mm, whichever is higher and the diameter shall not be less than 180 mm.

926.2.4. **Particular recommendations for confined PTFE**

926.2.4.1. PTFE shall be located into recess of a sufficiently rigid metal backing plate by confinement and shall either be dimpled large sheet(s) or an array of solid (i.e., without dimples)

rectangular modules of size 80 mm × 50 mm. The dimpled large sheets shall be circular or rectangular in shape and may be subdivided into a maximum of four parts. For dimpled sheets with smallest dimension (diameter or smaller side) exceeding 100 mm, contact area shall be taken as the gross area without deduction for the area of the dimples. In arrayed PTFE layout the distance between the individual modules shall not be more than 10 mm. The shoulders of the recess should be sharp and square to restrict the flow of PTFE. The thickness of the PTFE and its protrusion from the recess should be related to its maximum plan dimension in accordance with Table 4.

Table 4. Dimension of Confined PTFE

Maximum dimension of PTFE (diameter or diagonal) (mm)	Minimum thickness (mm)	Maximum protrusion above recess (mm)
≤ 600	4.5	2.0
> 600, ≤ 1200	5.0	2.5
> 1200, ≤ 1500	6.0	3.0

926.2.4.2. Characteristic maximum coefficient of friction for stainless steel sliding on uniformly lubricated PTFE shall be as per Table 5. Linear interpolation may be used for intermediate values. In absence of test data the coefficient of friction of unlubricated PTFE on stainless steel should be taken as twice the value as given in Table 5. For design purposes, induced horizontal force caused by the resistance to translational movement due to friction at the PTFE-stainless steel interface shall be determined considering the PTFE as unlubricated.

TABLE 5. COEFFICIENT OF FRICTION FOR STAINLESS STEEL SLIDING ON PROPERLY LUBRICATED PTFE

Average pressure on confined PTFE (MPa)	Maximum coefficient of friction
5	0.08
10	0.06
20	0.04
≥ 30	0.03

926.2.4.3. Average pressure on confined PTFE shall not exceed 40 MPa and extreme fibre pressure shall not exceed 45 MPa.

926.2.4.4. No increase in permissible limits of stresses is allowed for seismic, wind or any other load combinations.

926.2.5. **Permissible limits in bolts and screws**

926.2.5.1. For bolts and screws of property class 4.6 (Ref. IS:1367) permissible stress in axial tension σtf shall not exceed 120 MPa.

926.2.5.2. For bolts and screws of property class 4.6 (Ref. IS:1367) permissible stress in shear τvf shall not exceed 80 MPa.

926.2.5.3. For bolts and screws of property class 4.6 (Ref. IS:1367) permissible stress in bearing σpf shall not exceed 250 MPa.

926.2.5.4. The permissible stresses in bolts and screws of property class higher than 4.6 shall be those given above multiplied by the ratio of its yield stress or 0.2 per cent proof stress or 0.7 times its tensile strength, whichever is lesser, to 235 MPa.

926.2.5.5. For bolts and screws subject to both shear and axial tension, the following expression shall be satisfied:

$$\tau vf,cal/\tau vf + \sigma tf,cal/\sigma tf \leq 1.4$$

Where,

$\tau vf,cal$ = calculated value of shear stress,
$\sigma tf,cal$ = calculated value of tensile stress.

926.2.5.6. When the effect of wind or earthquake is taken into account, the above permissible stresses shall not be increased.

926.2.6. **Permissible stresses for welds**

926.2.6.1. The permissible stress in fillet weld based on its throat area shall be 110 MPa.

926.2.6.2. The permissible shear stress on plug welds shall be 110 MPa.

926.2.6.3. No increase in permissible limits of stresses is allowed for seismic, wind or any other load combinations.

926.3. **Design Philosophy**

926.3.1. **Particular recommendations for design of Pot and Pot-cum-PTFE bearings**

926.3.1.1. Stress distribution through the bearing component adjacent to the (supported/supporting) structure as well as on the structure itself due to active load, force and induced force and moment produced due to resistance to movement and rotation shall be determined with due considerations to the relative stiffness and interaction of the bearing component and the adjacent structure by a suitable method, e.g., three dimensional finite element (3D-FEM)

method of analysis. In absence of elaborate 3D-FEM analysis, design procedure specified in Clauses 926.3.1.1.6 and 926.3.1.1.7 may be adopted to determine the dimensions of bearing components. However, for Pot bearings of vertical load capacity 7500 kN or higher the pot cylinder shall always be analysed by three-dimensional finite element method of analysis. Only internationally accepted, authentic software shall be used for carrying out 3D-FEM analysis.

926.3.1.1.1. To carry out 3D-FEM analysis, bearing component and the adjacent structure shall be modelled together. For concrete structure, a block of concrete shall be considered for modelling together with the adjacent bearing component. The area of the block shall be geometrically similar to the contact area and also the largest area that can be contained in the plane of contact of bearing and structure. The depth of the concrete block shall be equal to the minimum available depth of the adjacent component of the concrete structure over the area of the block. The depth of concrete block need not exceed the largest dimension (diameter or diagonal) of the bearing component along the contact plane.

926.3.1.1.2. For concrete elements, Poisson's ratio may be assumed as 0.2, and modulus of elasticity may be assumed as follows:

$$Ec = 5000\sqrt{fck}$$

Where,

Ec is the short-term static modulus of elasticity in MPa and fck is the characteristic cube strength of concrete in MPa. The value of elastic modulus for permanent load effect (Ece) may be assumed to be equal to 50 per cent of short-term static modulus of elasticity, i.e., Ece = 0.5Ec.

For steel elements static modulus of elasticity, Es, may be considered as 2×10^5 MPa and the Poisson's ratio may be considered as 0.3.

926.3.1.1.3. The confined elastomeric pressure pad to be considered to act as fluid exerting fluid pressure under vertical load. In addition, design horizontal force that may coexist shall be taken into account for carrying out 3D-FEM analysis.

926.3.1.1.4. The average pressure on concrete structure adjacent to the bearing component shall not exceed the permissible value given in Clause 926.2.1 and the peak stress shall not exceed 0.75 $f$ck under any critical load combination.

926.3.1.1.5. Critical values of tensile, shear and bending stresses on the bearing component as found from 3D-FEM analysis result, shall not exceed the permissible values given in Clause 926.2.2. Critical value of equivalent stress may either be derived by a suitable method or the critical values of Von-Mises stress suitably added for the critical load combination may be considered and checked against permissible value of equivalent stress as given in Clause 926.2.2.5.

926.3.1.1.6. **Simplified design rule**

926.3.1.1.6.1. In absence of 3D-FEM analysis, load distribution through the bearing component(s) and to the adjacent structure shall be calculated considering effective contact area after one Vertical to two Horizontal (1V:2H) distribution of confined elastomer stress as shown in Fig. 27. Flexural stress due to active and induced moments shall be calculated considering the section modulus of the effective contact area as shown in Fig. 27. Average contact stress, flexural stress and the combined effect shall not exceed the limiting values as specified in Clause 926.2. For dispersion through sliding components it should be ensured that the dispersed area is contained within the particular component, even when maximum design displacement occurs.

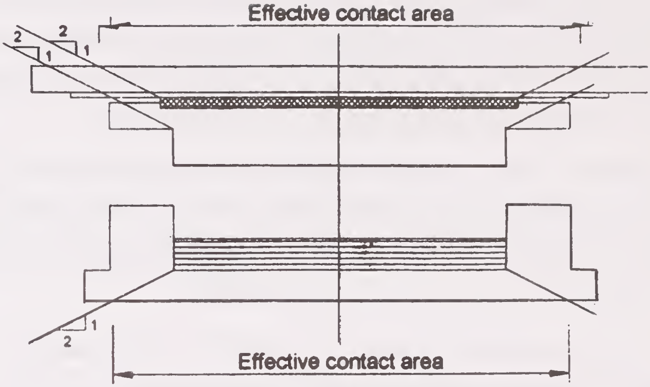


Fig. 27. Load dispersion through bearing components

926.3.1.1.7. In absence of 3D-FEM analysis, the dimensions of the cylinder wall shall be determined using expressions given in Clauses 926.3.1.1.7.1 to 926.3.1.1.7.4, which are based on the effect of coexisting load/forces under any critical combination. The confined elastomeric pressure pad is considered to act as fluid exerting fluid pressure under vertical load, (Fig. 28).

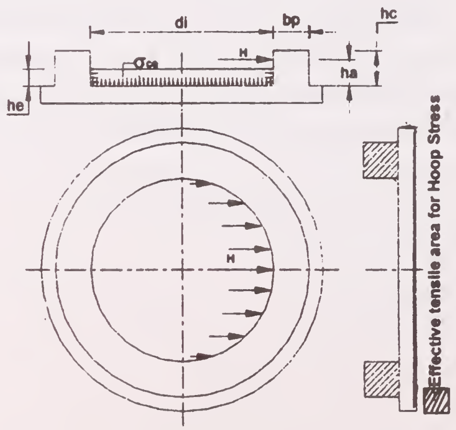


Fig. 28. Design principle of cylinder wall

926.3.1.1.7.1. Hoop tensile stress in the cross section of cylinder wall due to:

(i) Fluid pressure, $\sigma at_1 = (di \times he \times \sigma ce)/(2 \times bp \times hc)$
(ii) Horizontal force, $\sigma at_2 = H/(2 \times bp \times hc)$

Where,

di = diameter of confined elastomeric pressure pad in mm,
he = thickness of confined elastomeric pressure pad in mm,
σce = fluid pressure in confined elastomeric pressure pad due to vertical load in MPa,
bp = thickness of cylinder wall in mm,
hc = height of cylinder wall in mm,

Total Hoop tensile stress ($\sigma at,cal$) due to fluid pressure and horizontal force, i.e., $\sigma at_1 + \sigma at_2$, shall not exceed the value of permissible stress in axial tension as specified in Clause 926.2.2.

926.3.1.1.7.2. Shear stress at cylinder wall and base interface calculated considering 1mm radial slice of the cylinder due to:

(i) Fluid pressure, $\tau vm_1 = (he \times \sigma ce)/bp$
(ii) Horizontal force, $tvm_2 = 1.5 \times H/(di \times bp)$

Where,

Parabolic distribution factor is considered as 1.5.

Total shear stress (τvm, cal) due to fluid pressure and horizontal force, i.e., $\tau vm1 + \tau vm2$, shall not exceed the value of permissible stress in shear as specified in Clause 926.2.2.

926.3.1.1.7.3. Bending stress at cylinder and base interface calculated considering 1mm radial slice of the cylinder due to:

(i) Fluid pressure, $\sigma bt1 = (6 \times \sigma ce \times he^2)/(2 \times bp^2)$
(ii) Horizontal force, $\sigma bt2 = 1.5 \times 6 \times H \times ha/(di \times bp^2)$

Where,

ha = height of line of application of design horizontal force from cylinder wall above base interface in mm,
H = design horizontal force in N,

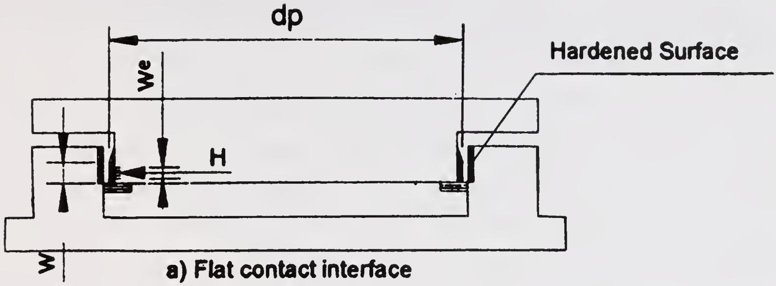
Parabolic distribution factor is considered as 1.5.

Bending stress ($\sigma_{bt,cal}$) due to fluid pressure and horizontal force, i.e., $\sigma_{bt1} + \sigma_{bt2}$, shall not exceed the value of permissible bending stress as specified in Clause 926.2.2.

926.3.1.1.7.4. Equivalent stress ($\sigma_{e,cal}$) due to combined bending and shear shall be checked in accordance with Clause 926.2.2.5.

926.3.1.2. Minimum thickness of cylinder base shall not be less than 2.5 per cent of the inner diameter of the pot cylinder. Minimum thickness of the steel backing plate of stainless steel for sliding component shall not be less than 2.5 per cent of the maximum dimension (diameter or diagonal) in plan. However, minimum thickness of any steel component or part thereof shall in no case be less than 12 mm.

926.3.1.3. The mating interface of piston and cylinder shall be designed to withstand the design horizontal force and suitably detailed to facilitate rotational movement. The ability of the contact surfaces to withstand deformation under load and wear due to rotational movement of the piston is dependent on the surface hardness of the contact surfaces at the mating interface. The surface hardness of the contact surfaces at the mating interface shall be in accordance with Clause 927.2.2. The contact surface of the piston may be flat in accordance with Clause 926.3.1.3.1 provided the width of the piston contact surface, w, is less than 15mm. If the width of the contact surface, w, is greater than 15mm then the contact surface shall be curved in accordance with Clause 926.3.1.3.2, (Fig. 29).



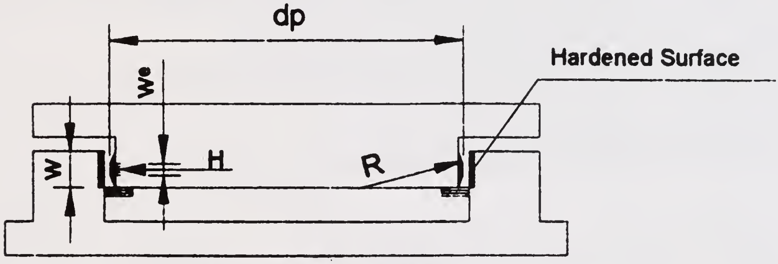


Fig. 29. Detail of piston-cylinder mating interface

926.3.1.3.1. Effective contact width, w_e of the flat contact surface shall be calculated using the following expression:

$$w_e = (1.3 \times H)/\sigma p \times dp$$

Where,

H = design horizontal force in N.

σp = permissible bearing stress of the steel material of the piston or the cylinder, whichever is lower in MPa as per Clause 926.2.2.

dp = diameter of piston in mm.

Effective contact width, w_e shall not exceed the width, w, of the flat contact surface.

926.3.1.3.2. Curved contact surface shall be designed using the following expressions:

$$\sqrt{\{(H \times Es)/(18 \times R \times dp)\}} \leq \sigma u,$$

$$w_e + \theta \times dp \leq w, \text{ and}$$

$$w_e = 3.04 \sqrt{\{(H \times R)/(Es \times dp)\}}$$

Where,

σu	=	ultimate tensile strength of the steel material of the piston or the cylinder, whichever is lower in MPa
Es	=	static modulus of elasticity of steel in MPa
R	=	radius of curvature of the curved contact surface in mm
θ	=	design rotation in radian
w_e	=	effective contact width of contact surface in mm

926.3.1.3.3. The minimum theoretical depth of effective contact width of piston at design rotation shall not be less than 5 mm, (Fig. 30).

926.3.1.4. The minimum theoretical clearance between the top edge of cylinder and the bottom edge of piston at design rotation shall not be less than 5 mm, (Fig. 30).

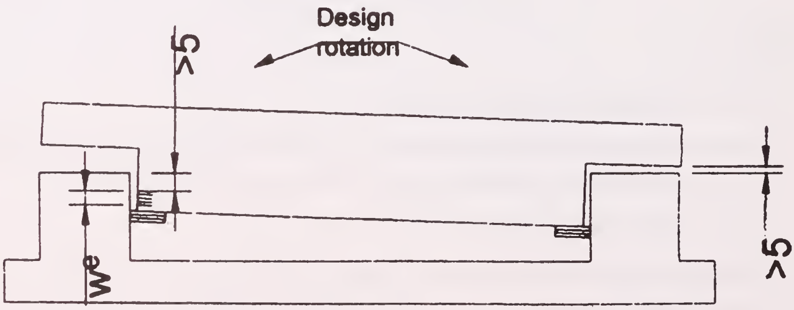


Fig. 30. Interconnection and clearance of components

926.3.1.5. For sliding components stainless steel sheet shall be attached to its backing plate by continuous fillet welding along the edges. The stainless steel surface shall always overlap the PTFE even when the extreme movement occurs. The welded connection shall be designed to withstand only the induced force generated at the sliding interface due to friction. The thickness of stainless steel shall be derived from the requirement of proper welding and in no case shall be less than the thickness of the weld or 3 mm, whichever is higher.

926.3.1.6. Guides shall be designed in accordance with Clause 926.3.5.

926.3.1.7. Anchoring arrangement shall be designed in accordance with Clause 926.3.6.

926.3.2. **Particular recommendations for design of PTFE sliding assemblies**

926.3.2.1. PTFE sliding assemblies shall normally be provided as plane sliding interface capable to cater for translational movements. PTFE sliding assemblies should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding. To accommodate rotation about an axis in the plane of sliding additional arrangement shall be provided, e.g., PTFE sliding assemblies may be combined with other types of bearings like, elastomeric bearings, metallic rocker bearings, Pot bearings, etc.

926.3.2.2. Presetting of top plate may be allowed, if necessary, while dimensioning it.

926.3.2.3. PTFE sliding assemblies shall preferably have the larger of the sliding surfaces positioned above the smaller, so that the sliding surfaces are kept clean.

926.3.2.4. Surfaces mating with PTFE shall always be made of stainless steel. The mating stainless steel surface shall always overlap the PTFE even when the extreme movement occurs.

926.3.2.5. Load distribution through the bearing component and to the adjacent structure shall be calculated considering effective contact area after one Vertical to two Horizontal (1V : 2H) dispersion of confined PTFE stress. Flexural stress due to moment resulting from the effect of active and induced horizontal force shall be calculated considering the section modulus of the effective contact area. Average contact stress, flexural stress and the combined effect on the adjacent structure shall not exceed the limiting values as specified in Clause 926.2. For dispersion through sliding components it should be ensured that the dispersed area is contained within the particular component, even when maximum design displacement occurs.

926.3.2.6. Minimum thickness of any component shall not be less than 2.5 per cent of the maximum dimension (diameter or diagonal) in plan or 12 mm, whichever is higher.

926.3.2.7. Guides shall be designed in accordance with Clause 926.3.5.

926.3.2.8. Anchoring arrangement shall be designed in accordance with Clause 926.3.6.

926.3.3. **Particular recommendations for design of Pin bearings**

926.3.3.1. For Pin bearings the pin shall be designed to withstand the design horizontal force considering the effect of coexisting design rotation. The diameter of pin shall in no case be

less than 150 mm. The inner diameter of the cylinder shall be in accordance with the tolerance of fit specified in Clause 927.1.4.3.

926.3.3.2. The mating interface of pin and cylinder shall be designed to withstand the design horizontal force and suitably detailed to facilitate rotational movement. The ability of the contact surfaces to withstand deformation under load and wear due to rotational movement of the pin is dependent on the surface hardness of the contact surfaces at the mating interface. The surface hardness of the contact surfaces at the mating interface shall be in accordance with Clause 927.2.2. The contact surface of the pin shall be provided with a radius of curvature equal to the radius of the pin and the contact surface of the cylinder shall be provided with a radius of curvature equal to the inner radius of the cylinder. The mating interface shall be designed in accordance with Clause 926.3.3.2.1, (Fig. 31).

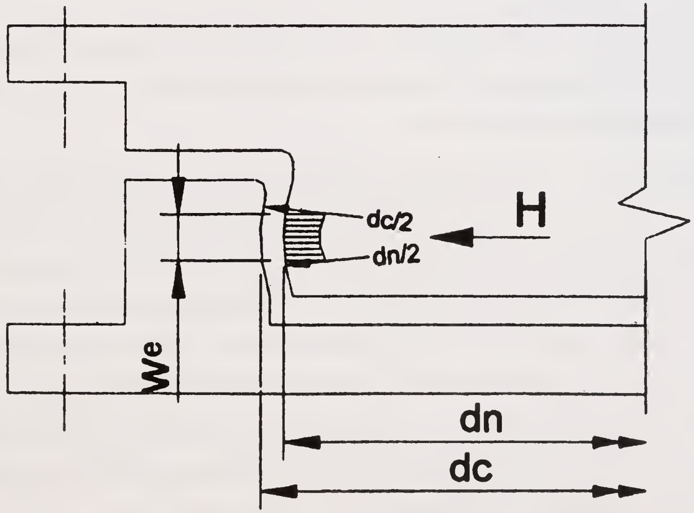


Fig. 31. Detail of pin-cylinder contact interface

926.3.3.2.1. The effect of the Hertz stress (σp,Hertz) at the mating interface shall be calculated using the following expression:

$$\sigma p,\ Hertz = 0.6 \sqrt{[\{(H \times Es)/(w_e \times dc)\} \times (1\text{-}dn/dc)]}$$

Where,

H = design horizontal force in N,

Es = static modulus of elasticity of steel in MPa.

w_e = effective contact width of contact surface in mm,

dc = inner diameter of cylinder in mm.

dn = diameter of pin in mm.

σp, Hertz shall not exceed the value of permissible bearing stress as specified in Clause 926.2.2.

926.3.3.2.2. The effective contact width of the pin, w_e, at design rotation shall be contained within the curved profile of the cylinder at the mating interface.

926.3.3.3. The minimum theoretical clearance between the top edge of cylinder and the bottom edge of pin at design rotation shall not be less than 5 mm.

926.3.3.4. The resultant of the coexisting moments produced due to design horizontal force and that induced due to resistance to rotation, if any, shall not exceed the moment of resistance of the group of anchor bolts/screws/studs. The moment of resistance of the group of anchor bolts/screws/studs shall be determined considering the position of the neutral axis of the group of bolts/screws/studs, along the centerline of the bolt/screw/stud located at the edge of the group and parallel to the axis about which the resultant moment acts, (Fig. 32).

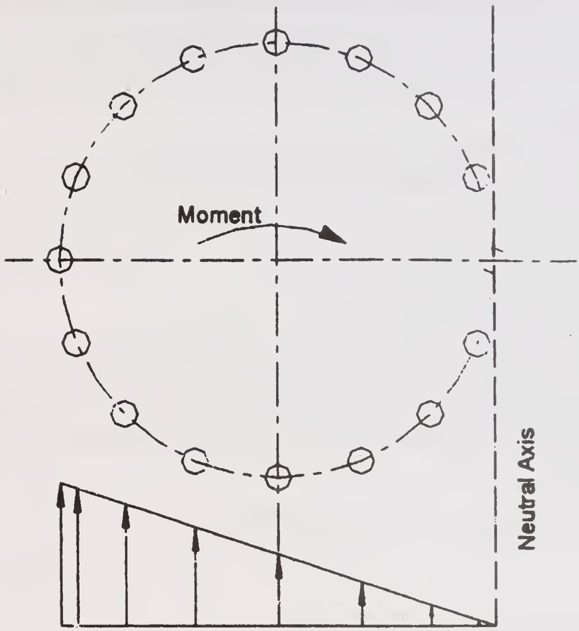


Fig. 32. Distribution of forces on bolt/screw/stud group

926.3.3.5. The combined effect of shear due to design horizontal force and tension due to the resultant moment in the anchor bolts/screws/studs shall be checked against respective permissible values as given in Clause 926.2.5.

926.3.3.6. The thickness of the plates of the Pin bearing through which it is connected to the structure shall be determined considering the effect of maximum tensile force that may occur on any bolt/ screw/stud due to resultant moment.

926.3.3.7. The dimensions of the cylinder wall shall be determined using expressions given in Clauses 926.3.3.7.1 to 926.3.3.7.4, which are based on the effect of design horizontal force on 1 mm radial slice of the cylinder.

926.3.3.7.1. Hoop tensile stress ($\sigma at, cal$) in the cross-section of cylinder wall calculated as per expression given below shall not exceed the value of permissible stress in axial tension as specified in Clause 926.2.2.

$$\sigma at, cal = H/(2 \times bp \times hc)$$

Where,

bp = thickness of cylinder wall in mm,
hc = height of cylinder wall in mm,

926.3.3.7.2. Shear stress ($\tau vm, cal$) at cylinder wall and base interface calculated as per expression given below shall not exceed the value of permissible stress in shear as specified in Clause 926.2.2.

$$\tau vm,cal = 1.5 \times H/(dc \times bp)$$

Where,

H = design horizontal force in N,
dc = inner diameter of cylinder in mm.
bp = thickness of cylinder wall in mm.

Parabolic distribution factor is considered as 1.5.

926.3.3.7.3. Bending stress ($\sigma bt, cal$) at cylinder wall and base interface calculated as per expression given below shall not exceed the value of permissible stress in bending as specified in Clause 926.2.2.

$$\sigma bt, cal = 1.5 \times 6 \times H \times ha/(dc \times bp^2)$$

Where,

ha = height of line of application of design horizontal force from cylinder wall and base interface in mm,

Parabolic distribution factor is considered as 1.5.

926.3.3.7.4. Equivalent stress (σe, cal) due to combined bending stress and shear stress shall be checked in accordance with Clause 926.2.2.5.

926.3.3.8. Minimum thickness of cylinder base shall not be less than 2.5 per cent of the inner diameter of the cylinder. Minimum thickness of any steel component or part thereof shall in no case be less than 12 mm.

926.3.4. Particular recommendations for design of metallic guide bearings

926.3.4.1. Metallic Guide bearings shall be provided to resist horizontal force along the direction perpendicular to the direction along which it allows movement. Metallic Guide bearings should not be used to accommodate rotation other than about an axis perpendicular to the plane of sliding.

926.3.4.2. Sliding interface shall always consist of stainless steel sliding on confined PTFE. The coefficient of friction at the sliding interface shall be in accordance with Clause 926.2.4.2 considering the PTFE as unlubricated. The mating stainless steel surface shall always overlap the PTFE even when the extreme movement occurs.

926.3.4.3. Minimum thickness of any component shall not be less than 12 mm.

926.3.4.4. The minimum theoretical vertical clearance between the sliding components at design rotation shall not be less than 5 mm, (Fig. 19).

926.3.4.5. Anchoring arrangement shall be designed in accordance with Clause 926.3.6.

926.3.4.6. The resultant of the coexisting moments produced due to active and induced design horizontal forces shall not exceed the moment of resistance of the group of anchor bolts/screws/studs. The moment of resistance of the group of anchor bolts/screws/studs shall be determined considering the position of the neutral axis of the group of bolts/screws/studs along the centerline of the bolt/screw/stud located at the edge of the group and parallel to the axis about which the resultant moment acts.

926.3.4.7. The combined effect of shear due to design horizontal force and tension due to the resultant moment in the anchor bolts/screws/studs shall be checked against respective permissible values as given in Clause 926.2.5.

926.3.4.8. The thickness of the plates of the Guide bearing through which it is connected to the structure shall be determined considering the effect of maximum tensile force that may occur on any bolt/screw/stud due to moment produced due to horizontal force.

926.3.4.9. The cantilever vertical projections of the Metallic Guide bearing shall be checked for bending, shear and combined stresses due to the effect of design horizontal force.

926.3.5. **Design of guides for Pot-cum-PTFE bearings and PTFE sliding assemblies.**

926.3.5.1. Sliding surfaces for guides of Pot-cum-PTFE bearings and PTFE sliding assemblies shall be made of stainless steel sliding on either confined PTFE or Composite Material or Stainless steel. The coefficient of friction at the sliding interface

of guides shall be considered as follows:

PTFE to stainless steel	:	value of coefficient of friction for unlubricated PTFE as given in Clause 926.2.4.2.
Composite Material to stainless steel	:	0.05
Stainless steel to stainless steel	:	0.2

926.3.5.2. For stainless steel sliding on stainless steel, bearing stress at the sliding interface of guides shall not exceed 150 MPa. When the effect of wind or earthquake is taken into account the above permissible stresses may be increased by 33.33 per cent.

926.3.5.3. For stainless steel sliding on composite material, pressure on composite material shall not exceed 70 MPa.

926.3.5.4. For stainless steel sliding on confined PTFE, pressure on PTFE shall not exceed the allowable average pressure as given in Clause 926.2.4.3.

926.3.5.5. Cantilever projection of guide shall be checked for shear, bending and combined stresses against permissible values specified in Clause 926.2.2.

926.3.5.6. Guides shall either be in the form of one guide bar located centrally on the piston of Pot-cum-PTFE bearing/fixed plate of PTFE sliding assembly or two guide bars attached side-wise to the sliding plate. For Pot-cum-PTFE bearings guiding off the fixed base, i.e., pot cylinder or any extension of it shall not be permitted.

926.3.5.7. Guides shall always be monolithic to the component to which it is connected. The thickness of the component to which the guide is connected shall in no case be less than the thickness of the guide, measured along the direction of horizontal force acting on the guide.

926.3.5.8. For central guides the thickness of the portion of sliding plate recessed to accommodate guide shall not be less than 0.3 times the thickness of the sliding plate or 0.3 times the width of the recess or 12 mm, whichever is higher (Fig. 33).

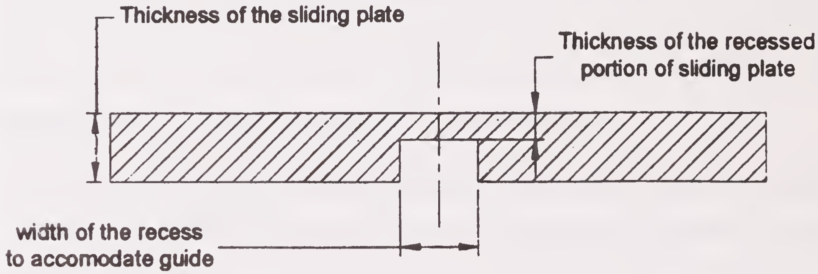


Fig. 33. Recess in sliding plate for central guide

926.3.5.9. For central guides the vertical clearance between the guide and the recessed sliding plate shall not be less than 0.2 per cent of the length of the recess or 2 mm, whichever is higher.

926.3.6. **Design of Anchoring Arrangement**

926.3.6.1. Bearings should be designed and detailed to make it replaceable with minimum lifting of the superstructure.

926.3.6.2. For the bearing plates in contact with concrete structure and subjected to loading normal to the plane of contact, substantial amount of friction is generated at the bearing-structure interfaces which helps in stabilising the horizontal force. There also exists a bond between the bearing plate and concrete. The horizontal force transmission capacity of the anchorage shall be considered as the sum of the friction force developed at the interface and the capacity of the anchorage to resist shear force. The

coefficient of friction at the bearing plate and concrete structure interface shall be considered as 0.2. To determine the contribution of friction in stabilising the horizontal force only the effect of load normal to the bearing-structure interface for any critical combination of loads and forces that may coexist, shall be considered, which, however, shall in no case be more than the permanent load. For high seismic zones (Zone IV & V), the contribution of friction in stabilising the horizontal force shall not be considered.

926.3.6.3. For bolts and screws the effective tensile area shall be considered, even for determining the shear capacity.

926.3.6.4. The diameter of the anchor sleeves shall in no case be less than twice the nominal diameter of bolts/screws (Fig. 34). Length of sleeve shall in no case be greater than five times its diameter.

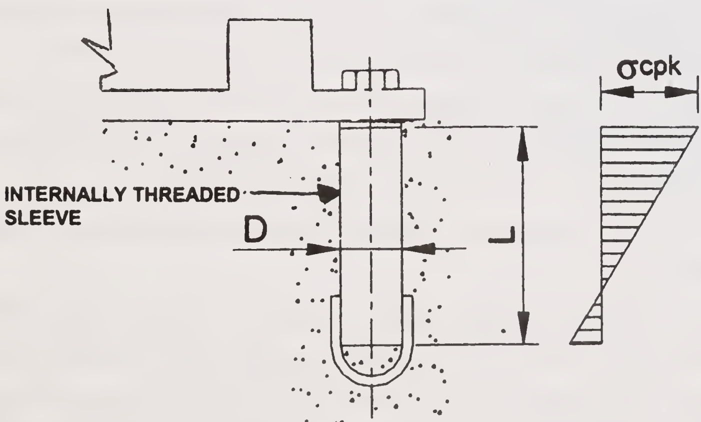


Fig. 34. Stress distribution in concrete adjacent to sleeve

926.3.6.5. The peak stress on the concrete adjacent to the anchor sleeve shall be calculated using the following expression,

which shall not exceed the permissible compressive flexural stress as given in Clause 926.2.1 (Fig. 34).

$$\sigma cpk = (3 \times Ab, eff \times \tau vf)/(D \times L)$$

Where,

σcpk	=	peak stress in concrete behind anchor sleeve in MPa.
Ab, eff	=	effective tensile area of the bolt/ screw to be fastened to the sleeve in mm^2,
τvf	=	permissible shear stress of bolt/screw as specified in Clause 926.2.5
D	=	diameter of sleeve in mm, and
L	=	length of sleeve in mm.

926.3.6.6. The threaded fastening length of bolt/screw of property class 4.6 shall not be less than 0.8 times its nominal diameter. For bolt/screw of higher property class either nut of same property class shall be used or the fastening length shall be determined by multiplying the length specified above by the ratio of the yield stress or 0.2 per cent proof stress or 0.7 times the tensile strength of the material of the bolt/screw, whichever is lesser, to 235 MPa.

926.3.6.7. The edge distance for bolt/screw shall not be less than 1.5 times the diameter of hole and the center-to-center distance shall not be less than 2.5 times the diameter of hole.

926.3.6.8. For temporary fasteners the above stipulations may be relaxed.

926.3.6.9. Anchor studs shall be made of forged steel. For adjacent structure made of concrete of grade M35 or above the length of stud, the diameter of stud head and the thickness of stud head shall not be less than 6 times, 2.5 times and 0.4 times the diameter of stud respectively and in that case the capacity of the studs in shear and tension may be derived considering the allowable stresses of material with property class 4.6 as given in Clause 926.2.5. Stud heads shall always be monolithic to the studs.

926.3.6.10. Center-to-center distance between studs shall not be less than 3 times the diameter of stud.

926.3.6.11. The connection of stud with the plate to which it is connected shall be properly designed.

926.3.6.12. Studs resisting tensile force shall be suitably arranged with staggered long and short studs. Minimum length of the studs shall in no case be less than the value specified in Clause 926.3.6.9 and the difference in length between short and long studs shall not be less than 3 times the diameter of stud.

927. MANUFACTURE

927.1. Manufacturing Tolerances

927.1.1. The overall dimensions of any assembled bearing or component thereof shall not exceed the following tolerance limits:

1.	Plan dimension of assembled bearing	:	- 0 mm to + 5 mm or 0.5 per cent of plan dimension, whichever is higher
2.	Overall height of assembled bearing	:	-0 mm to + 3 mm or 1 per cent of overall height, whichever is higher
3.	Parallelism of top surface of assembled bearing w. r. t. the bottom surface as datum	:	1 in 200
4.	Height of confined elastomeric pressure pad	:	-0 per cent to +5 per cent
5.	Thickness of any machined steel component	:	-0 mm to +1 mm
6.	Overall dimensions of any unmachined cast steel component	:	Class 2 of IS:4897
7.	Stainless steel sliding surface		
	(a) Flatness	:	0.0004L, where L = length in direction of movement
	(b) Surface finish	:	Ra $\leq$ 0.25 μm as per IS:3073

927.1.2. The tolerance on flatness of PTFE shall be 0.2 mm where the diameter or diagonal is less than 800 mm and 0.025 per cent of the diameter or diagonal where this dimension is greater than or equal to 800 mm. On PTFE surfaces made up of more than one piece of PTFE the above conditions shall apply to the diameter or diagonal dimension of the inscribing circle or rectangle around the PTFE. The tolerance of center-to-center distance of dimples, depth of dimples and diameter of dimples (Fig. 22) for dimpled PTFE sheet shall be ±0.5 mm, ±0.5 mm and ±1.0 mm respectively.

927.1.3. The dimensional tolerances of confined PTFE shall be as given in Table 6. The gap between the edge of the PTFE sheet and the edge of the recess in which it is confined shall not anywhere exceed 0.5 mm or 0.1 per cent of the corresponding plan dimensions of the PTFE sheet, in the direction measured, whichever is greater but in no case shall exceed 1mm. The profile tolerance on the specified projection of PTFE above its confining recess shall be as given in Table 6.

Table 6. Dimensional Tolerance of Confined PTFE and Profile Tolerance of its Projection

Maximum dimension of PTFE (diameter or diagonal) (mm)	Tolerance on plan dimension (mm)	Tolerance on thickness (mm)	Tolerance on specified projection above recess (mm)
≤ 600	±1.0	-0 to +0.5	-0 to +0.5
> 600, ≤ 1200	±1.5	-0 to +0.6	-0 to +0.6
> 1200, ≤ 1500	±2.0	-0 to +0.7	-0 to +0.8

927.1.4. Tolerance of fit between different components of bearings shall be as follows:

927.1.4.1. For Pot bearings the tolerance of fit between the piston and cylinder shall be +0.75 mm to +1.25 mm.

927.1.4.2. For Pot bearings the tolerance of fit between the confined elastomeric pressure pad and cylinder shall not exceed 0.5 per cent of the diameter of the pad or 1mm, whichever is higher.

927.1.4.3. For Pin bearings the tolerance of fit between the pin and cylinder shall be +1.5 mm to +2 mm. Manufacturing tolerances of the contact surfaces of pin and cylinder shall be as per h11 and H11 of IS:919 respectively.

927.1.4.4. The tolerance of fit between guide(s) and adjacent component shall be +2 mm to +4 mm.

927.2. **Manufacturing Method**

927.2.1. The main components of a bearing shall be cast/forged as a single monolithic body. If the same are made of mild steel, then these shall be machined to the desired shape from a single piece of lamination free mild steel element. No welding is permitted for manufacture of the main components of a bearing.

927.2.2. The mating surface of the piston and cylinder of Pot bearings and that of the pin and cylinder of Pin bearings shall be metallurgically hardened. The surface hardness shall not be less than 300 BHN.

927.2.3. The guides shall always be monolithic to the parent component.

927.2.4. Surfaces of bearings to be in contact with concrete structure as well as non-working external surfaces of components made of cast steel may be kept in as-cast condition.

927.2.5. For sliding components stainless steel sheet shall be attached to its backing plate by continuous fillet welding along the edges in such a fashion so as to ensure flatness of the stainless steel sheet throughout it's service life and avoid entrapment of air and prevent ingress of moisture at the interface. The backing plate shall extend beyond the edges of the stainless steel sheet to accommodate the weld and the weld should not protrude above the stainless steel sheet.

927.2.6. PTFE shall be secured in the recesses by suitable glue in addition to confinement. For large PTFE sheets subdivided into parts, each individual part shall be confined into separate recess.

927.2.7. For brass sealing ring type of internal seal, 2 mm thick and 20 mm wide split rings made of metallic brass shall be provided in layers with staggered split positions. Minimum two layers of rings shall be provided for elastomeric pressure pad of diameter upto 480 mm and minimum three layers of rings shall be provided for elastomeric pressure pad of diameter more than 480 mm.

927.2.8. For POM sealing chain type of internal seal, the sealing chain made of individual interlocking elements shall be moulded as an integral part of the elastomeric pressure pad during the vulcanisation process for proper functioning.

927.2.9. Any presetting of sliding element, if required, shall be done in the manufacturer's workshop before despatch.

927.2.10. Bearings shall be provided with temporary clamps to avoid separation of parts during transportation and erection.

927.2.11. All welding will be as per IS:816 & IS:9595 with electrode as per IS:814. Pre-heating and post-weld stress relieving to be done, if required.

927.2.12. Movement indicators should be provided to facilitate routine inspection during service period.

927.3. **Finishing**

927.3.1. All non working surfaces as well as the surfaces to be in contact with structure shall be suitably prepared by sand/shot blasting to SA 2½ quality as per IS:9954.

927.3.2. All non working surfaces shall be given suitable protective coating either by painting as per Clause 927.3.3 or by zinc spraying. The total dry film thickness of protective coating shall not be less than 160 μm.

927.3.3. Painted protective coating shall comprise of two coats of epoxy primer enriched with metallic zinc, one intermediate coat of high build epoxy paint reinforced with MIO (Micaceous Iron Oxide) and one coat of high performance epoxy finish paint as per paint manufacturer's specification.

927.3.4. Bearing components to be embedded in concrete structure or surfaces of any component to be in contact with concrete structure shall be given a coat of epoxy primer or any other suitable coating before despatch, to prevent corrosion during transportation and storage at site. The protective coating shall not affect the bond between the bearing component and the concrete.

927.3.5. Silicon grease shall be applied at the PTFE-stainless steel interface of Pot bearings.

927.3.6. Suitable lubricant which will not affect the material of the confined elastomeric pressure pad, shall be used to lubricate the pressure pad.

928. ACCEPTANCE SPECIFICATION

928.1. Bearings shall be manufactured to high standards both in terms of material quality and workmanship. The manufacturer shall have all test facilities required for process and acceptance control tests installed at his plant to the complete satisfaction of the inspector appointed by the concerned authority. The test facilities and their operation shall be open for inspection by the inspector.

928.2. All tests on raw materials and finished bearings shall be carried out as per procedures described in this section at the manufacturers workshop. All the test reports duly certified by the inspector shall be furnished by the manufacturer at the time of despatch of the bearing.

928.3. Acceptance testing shall be commenced with the prior submittal of testing programme by the manufacturer to the inspector and after obtaining his approval.

928.4. **Inspection Procedure**

928.4.1. Inspection and testing of the bearings shall require the following two types of tests:

928.4.1.1. **Type test :** Type test, which includes inspection and testing as per Clauses 928.6.2 and 928.6.3 shall be carried out

on bearings of each type and load capacity selected at random by the inspector once for each lot. The size of each lot for similar type of bearings shall be 25 nos. or part thereof. Each type of bearings shall be treated as separate lots. The term 'lot' means total quantity of bearings offered for inspection. The inspector may also carry out random tests as per Clause 928.6.1 on samples drawn by the manufacturer for such tests. In such cases the inspector may be present for identification and marking of the sample when it is drawn.

928.4.1.2. **Routine test :** Routine test, which includes inspection and testing as per Clauses 928.6.1, 928.6.2 and 928.6.3 shall be carried out by the manufacturer for the bearings of each lot under acceptance

928.4.2. The various inspection and tests may be classified into the following categories :

Raw materials inspection.
Inspection and testing of finished bearings.
Process inspection.

928.5. **Quality Control Report**

A detailed quality control report of routine test shall be furnished by the manufacturer to the inspector, for each lot of bearing offered for inspection.

928.6. **Detail of Tests**

928.6.1. **Tests on raw materials**

928.6.1.1. Test on raw materials as per relevant material standards shall be carried out by the manufacturer as per ***Appendix-2***.

928.6.2. **Inspection of finished bearings**

928.6.2.1. All bearings of the lot shall be visually inspected for absence of any defects in surface finish, shape or any other discernible superficial defects.

928.6.2.2. All bearings shall be checked for overall dimensions as per manufacturing tolerances specified in Clause 927.1.

928.6.2.3. At least one or a pair of bearings (depending on the requirement) of each type and different vertical load capacity selected at random shall be load tested as described below :

928.6.2.3.1. **Load test:** Bearings shall be load tested for direct loads for a test load equal to 1.25 times the specified design vertical load for Pot and PTFE bearings or to 1.25 times the specified design horizontal load for Pin and Metallic Guide Bearings. Additionally, for testing of Pot or PTFE bearings under a combination of loads acting in different axes the test loads shall be 1.1 times of the respective design loads. The test load shall be applied in stages and held for 30 minutes. For Pot bearings the vertical deflection under sustained test load shall not increase by more than 4 per cent of the thickness of the confined elastomeric pressure pad. The load shall then be removed and the bearing shall be dismantled and visually examined as given in Clause 928.6.2.3.4.

928.6.2.3.2. **Friction test:** For bearings with sliding component friction test shall be performed on properly lubricated PTFE-stainless steel sliding interface at constant vertical load equal to the i) design vertical load and ii) permanent vertical load. The horizontal load shall be applied till sliding occurs. Co-efficient of friction (μ) shall be determined on the basis of applied vertical

and horizontal load. The value of coefficient of friction shall not exceed 2/3rd of the value specified in Clause 926.2.4.2 depending on the actual average pressure on PTFE due to the applied vertical load.

928.6.2.3.3. **Rotation test:** Rotation test shall be performed on Pot bearing with properly lubricated elastomeric pressure pad for design rotation, under a constant vertical load equal to permanent vertical load.

928.6.2.3.4. The test bearing(s) shall be visually examined both during and after the test. Any resultant visual defects, such as, physical destruction, cold flow of PTFE resulting in reduction of projected height beyond 0.5mm, damage of internal seal and/or extrusion of the confined elastomeric pressure pad for Pot bearing, defects/cracks at metal-to-metal contact surfaces etc. shall cause rejection.

928.6.3. **Process Inspection**

928.6.3.1. **Test on welding:** DP test and visual inspection as per IS:822.

928.6.3.2. The hardness of all major steel components shall be tested to determine the Brinnel Hardness Number (BHN) which shall not be less than 120 BHN for mild steel, 150 BHN both for cast steel and forged steel.

928.6.3.3. All major metallic components shall be ultrasonically tested for soundness as per Level:3 of IS:9565.

928.6.3.4. **Surface hardness:** The surface hardness of the mating interface shall be checked in accordance with the requirement specified in Clause 927.2.2.

928.6.3.5. **Corrosion protection:** Corrosion protection measures shall be checked in accordance with the requirement specified in Clause 927.3.2.

928.7. In case of any evidence of process of acceptance control testing being deemed unsatisfactory by the inspector, complete bearing or particular component(s) of the entire lot may be rejected depending on the cause of rejection, i.e., if the raw material testing result of any material is unsatisfactory the component(s) involving that material shall be rejected for the entire lot but if a finished bearing fails in load test the complete bearing shall be rejected and all the bearings of that type and load capacity shall be load tested before acceptance. If the result of process inspection is unsatisfactory, proper rectification measures should be adopted and the acceptance test(s) shall be repeated.

929. CERTIFICATION AND MARKING

929.1. Bearings should be transported to bridge site after final acceptance by the inspector/inspection agency appointed by the concerned authority and shall be accompanied by an authenticated copy of the certificate to that effect.

929.2. It is desirable to list the required bearing characteristics in a consistent and comprehensive manner in an information card duly certified by the manufacturer and append the same with the inspection certificate.

929.3. All bearings shall have suitable index markings made of indelible ink or flexible paint, which if practicable shall be visible after installation, identifying the following information:

- Name of manufacturer
- Month and year of manufacture
- Bearing designation
- Type of bearing
- Load and movement capacity
- Centerline markings to facilitate installation
- Direction of major and minor movement, if any
- Preset, if any

930. INSTALLATION

930.1. General

930.1.1. Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure. Bearings shall be so located as to avoid the accumulation of dirt and debris likely to interfere with their performance and the structure so detailed that water is prevented from reaching the bearings.

930.1.2. In order that moving surfaces are not contaminated, bearings should not normally be dismantled after leaving the manufacture's workshop but if for any reason they are, then this should only be done under expert supervision and the manufacturer's assistance should be sought.

930.1.3. Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding material to resist the applied load. Temporary clamping devices should be removed at the appropriate time before the bearings are required to accommodate movement. Consideration should be given to any treatment required to holes exposed on the removal of temporary transit clamps. Where reuse of these fixing holes may be required, the material selected to fill them should not only give protection against deterioration but also should be easily removable without damaging the threads.

930.1.4. Suitable temporary supporting arrangements under bearing base plates should be made to accommodate thermal movement and elastic deformation of the incomplete superstructure, if necessary. Such temporary supports, if provided, should be compressible under design loading or removed once the bedding

material has reached the required strength. Any voids left as a consequence of their removal should be made good using the same type of bedding material. Steel folding wedges and rubber pads are suitable for such temporary supports under bearing base plates.

930.1.5. The installation tolerance given in Clause 930.5 may be relaxed, provided the same has been taken care of in the design of the structure.

930.2. **Bedding**

930.2.1. The choice of bedding materials is influenced by the method of installation of the bearings, the size of the gap to be filled, the strength required and the required setting time. When selecting the bedding material, consideration should, therefore, be given to various factors, like, type of bearing, size of bearing, loading on bearing, construction sequence and timing, early loading, friction requirements, access around the bearing, thickness of material required, design and condition of surface in the bearing area, shrinkage of the bedding material.

930.2.2. It is essential that the composition and workability of the bedding material be specified with the above factors in mind. In some cases, it may be necessary to carry out trials to ascertain the most suitable material. Commonly used materials are cementitious or chemical resin mortar and grout.

930.2.3. To ensure even loading on bearings and the supporting structures, it is essential that any bedding material whether above and below the bearing, extend over the whole area of the bearing.

930.2.4. Bearings shall be bedded over their whole area. After installation there shall be no voids or hard spots. The bedding

material shall be capable of transmitting the applied load to the structure without damage. Surfaces to receive bedding mortar shall be suitably prepared to a state compatible with the mortar chosen. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

930.3. **Fixing of Bearings**

930.3.1. To cater for vibration and accidental impact, some anchorage should be provided. Anchorage should be accurately set into recesses cast into the structure using templates and the remaining voids in the recesses should be filled with material capable of withstanding the loads involved.

930.3.2. Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Finally, voids beneath the bearings should be completely filled with bedding material using the appropriate method.

930.3.3. Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure to the correct level and location.

930.3.4. If the structure is of steel, the bearings may be bolted directly to it. Proper care shall be taken to ensure that there are no mismatch in the bolt holes of the structure and the bearing.

930.3.5. Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.

930.4. **Bearings Supporting In-Situ Concrete Deck**

930.4.1 Where bearings are installed prior to forming an in-situ concrete deck, formwork around bearings should be

carefully sealed to prevent grout leakage. However, it is essential that the bearings and particularly the working surfaces be protected during concreting operations. Sliding plates should be fully supported and care taken to prevent tilting, displacement or distortion of the bearings under weight of wet concrete. Any mortar contaminating the bearings should be completely removed before it sets.

930.4.2. For bearings supporting precast concrete or steel elements a thin layer of synthetic resin mortar should be used between bearings and precast concrete beams. Bearings shall be bolted to anchor plates or sleeves embedded in precast elements, or to machined sole plates on steel elements.

930.5. **Installation Tolerances**

930.5.1. The tolerances given in Clause 930.5.2 shall be observed unless otherwise specified.

930.5.2. Bearings shall be located so that their centrelines are within +/- 3 mm of their correct position. The level of a bearing or the mean levels of more than one bearing at any support shall be within a tolerance of +/- 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding +/- 5 mm. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction unless otherwise specified, even under superstructure in gradient.

931. MAINTENANCE

931.1. This section stipulates the requirements for inspection and maintenance of Pot, PTFE, Pin and Metallic Guide bearings during service period. Bearings should be designed and manufactured to make it maintenance free so that it can eliminate undesirable effects caused by extreme atmosphere or aggressive

environmental condition/unforeseen events. However, the surrounding area of the bearings shall always be kept clean and dry to avoid damage to the bearings.

931.2. Suitable easy access to the bearing shall be provided for inspection and maintenance. Provision shall be made for jacking up the superstructure so as to allow repair/replacement of the bearings.

931.3. Inspection of bearing at site is required from time to time to ascertain the performance of the bearings. Periodic nominal maintenance of bearing shall be carried out in order to ensure better performance and longer life of the bearings. The bearings are required to be inspected at an interval of one year for the first five years and at an interval of two years thereafter. However, the bearings shall also be examined carefully after unusual occurrences, like, heavy traffic, earthquakes, cyclones and batterings from debris in high floods.

931.4. The inspection shall be preceded by careful cleaning of the bearings as well as its surrounding space, depending on the actual conditions around the bearings, e.g., deposit of salt, debris, dust or other foreign material.

931.5. **Elements of Inspection**

The following are recommended inspection elements and actions which are considered necessary to monitor and upkeep the bearing :

(1) **Measurement of movement :** During inspection at site, measurements are required to be taken and documented to compute its movement and rotation values in relation to their design values to ascertain whether the performance of the bearings are satisfactory. To ascertain maximum movement, measurement should be taken once during peak winter (early morning) and once during peak summer (afternoon) and corresponding atmospheric temperature should be recorded. The recorded value of

movement shall be compared with the design values.

(2) **Measurement of dimensions :** Overall dimensions of the bearings are required to be measured and compared with the actual dimensions to ascertain any excessive stress or strain on the bearing.

(3) **Evidence of locked in condition :** If any movable or rotating part of a bearing is found to be in locked-in/jammed condition, necessary rectification measures shall be taken immediately.

(4) **Evidence of corrosion :** If corrosion of any part of exterior exposed steel surface of the bearing is detected the following measures may be taken. In addition, the root cause of defect should be searched and proper actions should be taken to avoid recurrence of the problem.

- Detect affected part
- Wire brush the affected portion to clean of it's rust.
- Apply protective coating as per manufacturer's specifications.

(5) **Condition of the adjacent bridge structure :** The adjacent structure of the bearings are also required to be inspected for any damage and necessary actions to repair the same, should be taken immediately.

931.6. Results and Actions

The results of every inspection has to be recorded in the inspection report and shall be classified in each case into the following types of action:

X	No action.
XX	Further measurements/long-term monitoring or design analysis needed (e.g., considering extreme temperatures/exposures, variation of loads, etc.). Actions to be outlined in a report.
XXX	Minor repair works e.g. cleaning, repainting, etc.
XXXX	Repair or replacement of entire bearings or parts of the bearings. Actions to be outlined in a report.

In case of defects where the cause of necessary actions cannot be determined by the inspecting person or the responsible bridge engineer, the bearing manufacturer shall be consulted.

Appendix-1

TYPICAL FORMAT OF FURNISHING DATA FOR DESIGN OF BEARINGS

General Data :

1. Structure is Located in Seismic Zone :
2. Material for Substructure : Concrete/Steel   If Concrete, Grade:
3. Material for Superstructure : Concrete/Steel   If Concrete, Grade:

Sl No	Bearing Type	Load Condition	Coexisting Loads, Forces, Movements and Rotation Data										Qty (Nos)
			Vertical Load (kN)		Horizontal Force (kN)				Rotation (Rad)		Movement (mm)		
			Case	Magnitude	Longitudinal		Transverse		Case	Magnitude	Longitudinal	Transverse	
					Case	Magnitude	Case	Magnitude					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1		Permanent	-		-		-		-				
		Normal	**Maximum**		Coexisting		Coexisting		Coexisting				
			Minimum		Coexisting		Coexisting		Coexisting				
		Seismic/Wind	**Maximum**		Coexisting		Coexisting		Coexisting				
			Minimum		Coexisting		Coexisting		Coexisting				
		Normal	Coexisting		**Maximum**		Coexisting		Coexisting				
		Seismic/Wind	Coexisting		**Maximum**		Coexisting		Coexisting				
		Normal	Coexisting		Coexisting		**Maximum**		Coexisting				
		Seismic/Wind	Coexisting		Coexisting		**Maximum**		Coexisting				
		Normal	Coexisting		Coexisting		Coexisting		**Maximum**				
		Seismic/Wind	Coexisting		Coexisting		Coexisting		**Maximum**				
2		Permanent	-		-		-		-				
		Normal	**Maximum**		Coexisting		Coexisting		Coexisting				
			Minimum		Coexisting		Coexisting		Coexisting				
		Seismic/Wind	**Maximum**		Coexisting		Coexisting		Coexisting				
			Minimum		Coexisting		Coexisting		Coexisting				
		Normal	Coexisting		**Maximum**		Coexisting		Coexisting				
		Seismic/Wind	Coexisting		**Maximum**		Coexisting		Coexisting				
		Normal	Coexisting		Coexisting		**Maximum**		Coexisting				
		Seismic/Wind	Coexisting		Coexisting		**Maximum**		Coexisting				
		Normal	Coexisting		Coexisting		Coexisting		**Maximum**				
		Seismic/Wind	Coexisting		Coexisting		Coexisting		**Maximum**				

Notes :

1. The type of bearing e.g., Fixed Pot/Free Sliding Pot-cum-PTFE/Guided Sliding Pot-cum-PTFE/Pin/Metallic Guide, etc. shall be specified in column (2)
2. Comprehensive data comprising of **Maximum/Minimum** and corresponding **Coexisting** Loads, Forces, Movements and Rotation shall be provided for each load condition and case.
3. i) For Pin and Metallic Guide Bearings, cells related to vertical load to be ignored; ii) For Free/Sliding Bearings cells related to Horizontal force along the direction of sliding shall be ignored and iii) For Fixed Pot Bearing and Pin Bearings, cells related to movements to be ignored.

Appendix-2

TESTS ON RAW MATERIAL

Sl.No.	Component to be tested	Procured From	Tests to be conducted	No. of Samples	Reference Documents	Acceptance Criteria	Testing Agency	Remarks
1.	Cast Steel		* Physical Tests: 1. Ultimate Tensile Strength (U.T.S.) 2. Yield Stress 3. % Elongation 4. Ultrosonic Test (Level-3)	One integral piece per heat	IS:1030	IS:10230	Independent Laboratory	Test certificates shall be furnished. However, random tests may be carried out by the inspector
			* Chemical Tests C, Mn; Si, S and P	-do-	-do-	-do-		-do-
2.	Mild Steel		* Physical Tests 1. Ultimate Tensile Strength (U.T.S.) 2. Yield Stress 3. % Elongation	One piece per plate	IS:2062	IS:2062	-do-	Steel manufacture's test certificates shall be furnished. However random tests be carried out by the inspector
			* Chemical Tests C, Mn, Si, S and P	-do-	-do-	-do-	-do-	-do-
3.	Forged Steel		* Physical Tests: 1. Ultimate Tensile Strength (U.T.S.) 2. Yield Stress 3. % Elongation	One piece per plate	IS:2004	IS:2004	-do-	Test certificates shall be furnished. However, random tests may be carried out by the inspector.

(Contd...)

Appendix-2 (Contd...)

Sl. No.	Component to be tested	Procured From	Tests to be conducted	No. of Samples	Reference Documents	Acceptance Criteria	Testing Agency	Remarks
			* Chemical Tests C, Mn, Si, S and P	-do-	-do-	-do-	-do-	-do-
4.	Mating Surface		1. Hardness			300 BHN	-do-	-do-
5.	Stainless Steel		* Chemical Tests C, Mn, Ni, Cr, Si, S, Mo and P	One piece per lot of procurement	AISI:316L	Test Certificate	-do-	Steel manufacturer's test certificates shall be furnished. However, random tests may be carried out by the inspector. In absence of manufacturer's certificate.
6	PTFE		1. Tensile strength at break 2. Elongation at break 3. Specific gravity 4. Durometer Hardness 5. Resistance to Heat 6. Dimensional stability	One per lot of procurement	As per BS:2782:301K BS:2782:301K BS:2782:509K Shore 'D; ASTM K 2240 BS:3784 BS:3784	Test Certificate	PTFE Manufacturer's Laboratory	PTFE manufacturer's Test Certificate shall be obtained.

(Contd...)

Appendix-2 (Contd...)

Sl. No.	Component to be tested	Procured From	Tests to be conducted	No. of Samples	Reference Documents	Acceptance Criteria	Testing Agency	Remarks
7.	Elastomer (Neoprene WRT/ Baypiene/ Denka)		* Physical Tests	From batches at random			Manufacturer's laboratory	Certificate of origin/shipping invoice towards import of chloroprene shall be furnished verification. Manufacturer's Test certificate of the raw material shall be provided However, random test may be carried carried out by the inspector.
			1. Hardness		IS:3400 (Part II)	IRHD 50±5		
			2. Min. Tensile strength		IS:3400 (Part I)	15.5 N/mm²		
			3. Minimum elongation		IS:3400 (Part I)	400%		
			4. Max. Compression set		IS:3400 (Part X)	As per IRC:83 (Part II)		
			5. Accelerated aging		IS:3400 (Part IV)	-do-		
8.	Bolts & Nuts		Physical & Chemical Tests	One for total lot	IS:1367	Test Certificate		Manufacturer's/ Dealer's Test certificate shall furnished.